THE ENGINEERING RECORD
PUBLISHED WEEKLY BY THE
McGraw Publishing Company
James H. McGraw, Pres.; Curtis E. Whittlesey, Sec. and Treas.
MAIN OFFICES:
239 WEST 39TH STREET, NEW YORK.
BRANCH OFFICES:
CHICAGO: Old Colony Building.
PHILADELPHIA: Real Estate Trust Building.
CLEVELAND: Schofield Building.
SAN FRANCISCO: Atlas Building.
LONDON OFFICE: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.
United States, Cuba and Mexico............$3.00 a year
Canada ....$4.50 a year
Foreign subscription..........................$6.00 a year
25 shillings. 25 marks. 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of THE ENGINEERING RECORD on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.

REMITTANCES.—Remittances should be made by check, New York draft, or money order, in favor of THE ENGINEERING RECORD.

CHANGE OF ADDRESS.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.

BACK COPIES.—No copies of issues prior to July, 1906, are kept on sale, except in bound volumes.

DATE ON WRAPPER indicates the month at the end of which subscription expires. The sending of remittances for renewal prior to that date will be much appreciated by the publishers.

CLUB RATE.—In acknowledgment of assistance rendered by subscribers in the securing of new orders, a club rate of $2.50 per annum is quoted. This rate applies to subscriptions in clubs of two or more, at least half of the names in the club to be those of new subscribers.

Entered at the New York Post-Office as Second Class mail matter.

Copyright, 1907, by the McGraw Publishing Co.

The circulation of THE ENGINEERING RECORD for 1907 was 763,000 copies, an average of 14,673 copies per week.

Of this issue 15,000 copies are printed.

TABLE OF LEADING ARTICLES.

The Plan for the Pacific End of the Panama Canal.. 29
Examinations for Professional Societies............ 29
From the Chief Engineer's Standpoint............ 30
Flexibility in Auxiliary Piping.................... 30
Industrial Engineering 31
The Flushing Tunnel for the Gowanus Canal in Brooklyn, N. Y. (Illustrated)........................ 32
An Electrically-Operated Pumping Plant............ 35
A Municipal Repair Plant for Pavements, New Orleans, La. (Illustrated) 35
An All-Concrete Laundry Building. (Illustrated).... 36
The Construction of the Queens Approach to the Blackwell's Island Bridge. (Illustrated).......... 38
Foundation Work for Six Lift Bridges. (Illustrated). 39
Arrangement of Railroad Shops. (Illustrated)....... 41
Sewage Distributors for Sprinkling Filters—Part I. (Illustrated) 46
A Boiler Furnace for Burning High-Volatile Coals. (Illustrated) 49
Structural Features of the Warwick Shops of the Lehigh & Hudson River Ry. (Illustrated)......... 50
Practical Aspects of Steam Railroad Electrification... 52
Book Notes 54
Breaking of Large Steel Beams..................... 55
Loads on Sewers. (Illustrated).................... 55
A Remarkable Cement Kiln Record................. 56
Tests of Bond Between Plain Bars and Concrete. (Illustrated) 56

The Plan for the Pacific End of the Panama Canal.

In The Engineering Record of a week ago there was a brief mention of the plans adopted for the Pacific end of the Panama Canal, by which three earth dams previously suggested for it, and hence Soza Lake, with the locks in Soza Hill, are to be avoided. There is to be substituted in the place of these suggested works a much shorter dam across the Rio Grande valley about three miles further inland at Miraflores, where two locks in flight on the twin system will be placed, this location being but about a mile nearer the Pacific than the single-lift twin locks at Pedro Miguel. The report of Lieut.-Col. Goethals on the subject is printed in the Current News Supplement of this issue. This modification of the original plan of the minority of the Board of Advisory Engineers is one of which the importance is probably realized by few engineers who have read the brief statement of it.

It will be remembered that the proposal to place an earth dam designed to hold 55 ft. head of water across the La Boca mud flats from San Juan point to Soza Hill was the subject of active discussion and strong expressions during the meetings of the International Board of Advisory Engineers. These mud flats are composed of a slimy ooze and soft unctious clay furnishing an ideal lubricant for the motion of any laterally pressed structure which could be made to rest upon it, and rendering such movement inevitable. As the plans contemplated the placing of the earth dam immediately upon this material without excavating it, and without the use of a core wall or other similar device, the Board, in its report referring to the canal as a great water way, stated "that the existence of such costly facilities for the world's commerce should not depend upon great reservoirs held by earth embankments, resting literally upon mud foundations, or those of even sand or gravel." The report of Lieut.-Col. Goethals describes what took place when the trial construction of the La Boca dam was begun. The ooze and clay were so soft and such a perfect lubricant that the material dumped from the construction trestle not only sank into the natural material, forming a slope as flat as one on twelve, with the formation of the usual mud and soft clay waves in front of the filling, but the trestle also sank as much as six to eight feet under its load. This was a matter of some surprise, apparently, as Lieut.-Col. Goethals quotes in his report the following statement by the engineers who examined and passed judgment upon the La Boca dam site, last April: "We do not think it will be necessary to remove the soft material at either of these places (Soza-Corozal, Soza-San Juan). The very softest material will either be displaced or consolidated with the material disposed on it. We do not think the amount displaced beneath the impervious portion of the embankment will be great, ..." The actual experience encountered in prosecuting the proposed plan of work was such as to show the necessity for further extended examinations with a view to the development of alternative plans for other Pacific terminal works for the canal. These investigations led to the consideration of four projects, one of which, approved by the President on Dec. 20, includes the construction of a dam on a rock foundation at Miraflores as already stated. The commission and Lieut.-Col. Goethals as its chairman, are to be highly commended for this substantial improvement in the canal plans, for it avoids the construction of great and costly works whose stability, if they could even have been put in place on the plans originally suggested, would have been most hazardously experimental.

It is interesting to observe that the estimated cost of the abandoned La Boca dams based upon the information secured in attempting to construct them, is nearly three times that of the minority of the Board of Advisory Engineers for the original plan. By placing the dam at Miraflores, furthermore, the cost of the works at the Pacific end of the Canal is reduced by over $7,000,000, basing estimated costs upon information now existing.

It is thus seen that the features of the canal on the Pacific side of the Isthmus are radically transformed by the adoption of this plan, and greatly for the better. Aside from the fundamental improvement in the new works as engineering constructions the dam and locks at Miraflores will be practically out of reach of the gun-fire of an enemy's fleet, a matter of material consideration in connection with the vulnerable character of any lock canal. There will be but one dam, and that a short structure not much longer than required for the two great twin locks. This greatly simplifies and reduces the cost of maintenance of the works, as there would otherwise have been three independent structures as dams or dykes, besides the two flights of twin locks. As there will be no Soza Lake the land damages will be correspondingly reduced and the town of La Boca, with its shops and pier together with the approaching railroad, will remain undisturbed.

It may, and probably will be, said that as the 500-ft. channel from Miraflores to the sea is a sea-level portion of the canal, the increased excavation necessary for it will be an item of increased cost of considerable magnitude. While this enhanced amount of excavation is large, its cost was included in the comparative estimates which showed a net gain by the changes of over $7,000,000 as compared with the cost of the plan of the minority of the Board of Advisory Engineers. Fortunately in this connection, according to Lieut.-Col. Goethal's report, the amount of rock found in the proposed channel between Miraflores and La Boca, as disclosed by the latest investigations, is much less than was at first anticipated. However that may be, there is the opportunity to excavate all the soft material by the cheapest kind of dredging operations. The rock also can be attacked by the most approved latest methods, including that of heavy chiseling. Wherever material can be gotten at by plants afloat, hand labor is largely reduced by a correspondingly increased employment of machinery, which, in the tropics, carries with it special advantages. The additional wide channel necessitated by this plan involves, therefore, only that class of excavation which can be done in a most economical manner. It is not a matter of surprise that the engineering organization on the Isthmus is reported to have felt a sense of great relief at this the latest evolution of Panama Canal experiences.

Examinations for Professional Societies.

The well-worn subject of examinations for the admission of applicants to national professional societies is up for discussion in Great Britain, where the Royal Institute of British Architects is considering the revision of its charter, dating from the reign of William IV. The feeling is apparently stronger in Great Britain than in the United States that either directly or indirectly some sort of protection should be afforded the public against unsafe structures, and this feeling takes the shape of a desire to make membership in the higher grades of the Institute essentially equivalent to a proof of proficiency in structural design. It is of course idle to expect that any sort of an examination can test an applicant's artistic abilities, although it may show his knowledge of the dry bones of architectural styles, and as a good many eminent architects hold that their profession is essentially artistic rather than structural, a good deal of feeling exists concerning what it is right to require in the way of examinations. While there is this lack of agreement concerning the terms under which an architect should be given admission to the upper grades of Institute membership, it would seem to a trans-Atlantic observer that the question is quietly and effectively being settled by current practice.

Admission to the Royal Institute of British Architects and the Institution of Civil Engineers is already a pretty zealously guarded honor. Very few architects or engineers in Great Britain have the ghost of a chance of election to full membership, but must join one of the lower grades and work their way upward by merit. Moreover, in order to secure admission to these lower grades, applicants must pass pretty stiff examinations or show diplomas from the best professional schools, and there is a belief expressed from time to time that diplomas should not be accepted in any case but that every applicant residing in Great Britain should be required to pass an examination. The examination questions that have reached this country are eminently fair and calculated to show how much knowledge of a scientific nature and how much technical information the applicants possess. The range of the questions set in any one examination is necessarily limited, but the questions submitted during a term of years cover quite as many things as the nature of the examinations warrants. In this respect the examinations are fairly comparable with those set by the courts for admission to the bar or by medical examiners for permission to practice medicine, and accordingly membership in the two great societies is already becoming equivalent to the certificates required by law before anyone may practice medicine or law. In other words, anybody who wishes to engage an architect or engineer in Great Britain and desires to select somebody having the same status as a physician or lawyer, has only to retain the services of one of those members of the two societies who has been admitted since the examinations went into force.

The subject is of interest to American engineers as an indication of a tendency already apparent on this side of the Atlantic to require something more than a college diploma as a certificate of proficiency in engineering or architecture. A number of States have passed laws requiring architects to take out licenses under conditions that will eventually tend to eliminate incompetent men, and a good many civil engineers have expressed the hope that something of the same sort might be done with members of their profession. Up to date the main stumbling block to any such legal action has been the fact that very few civil engineers come into contact with people in a professional way, but are employed on salary to serve under other engineers whom the law makes responsible for the work of their subordinates. It is clear that the chief engineer of an enterprise should be a man of such ability that he needs no legal charts to help him in the elimination of undesirable men from his staff, and so the professional standing of civil engineers in this country seems likely to be left for a long time to come with the American Society of Civil Engineers. Already membership in that body has become a sort of indication of proficiency, in the opinion of the public, but it is of course untenable that changes will not be made by the society from time to time which will make it more certain that none but fully competent men become members of its so-called corporate grades. Just what changes will be made it is not practicable to foresee at this time, although there may be some indication of future alteration in the suggestion heard from time to time that the society should have a committee which will keep in touch with the courses of instruction in American technical colleges and with the character of the examinations which lead to degrees in such schools. Whether this suggestion has ever had much consideration by the directors of the society this journal does not know, nor has it any idea that the members of the society feel that such a committee is desirable. There can be no question, however, that a good many of the members feel that in some way, direct or indirect, there should be greater protection afforded the public against unsafe work by incompetent men.

From the Chief Engineer's Standpoint.

The columns of The Engineering Record this week contain an abstract of a paper by Mr. W. N. Smith on the electrification of steam roads which is unusual in that it lays especial stress, not upon motive power, but upon the operating conditions. Of the many discussions of heavy electric traction published within the past ten years most have been devoted to a consideration of the saving in motive power costs attainable by changing to an electric system, and not a few have been written in evident exploitation of some particular system. Very few indeed have taken up the operating details of anything more elaborate than a suburban passenger system and these have mainly sung the praises of high acceleration, which could be increased indefinitely if only one were carrying pig iron instead of passengers. From the standpoint of the live load, accelerations are already quite as great as can readily be endured. But in point of fact, the great practical problems of railway electrification are those which have to do with the every-day handling of a huge mixed traffic under either existing conditions or those which can be very easily realized. Electrification thus far has been either in special situations, such as tunnels or terminals, or to meet particular local conditions. In the first case, on account of serious danger or of legal requirements, electric operation has become necessary even if considerably increased operating costs were thus caused. In the second case, one usually considers a substitution of motive power in dealing with a dense and homogeneous traffic on its own independent tracks and uncomplicated by general railway conditions.

Now every one is quite ready to admit that for heavy suburban passenger work and for tunnels and terminals, electric traction has great advantages quite irrespective of the absolute cost of motive power. These are not, however, types of the service into which it is proposed to extend electric traction, nor are they in any way proper examples of the practical difficulties to be met. Put yourself for a moment in the position of the chief engineer of a railroad, who is summoned to the president's office and charged with the responsibility of reporting a suitable project for the complete electrification of, let us say, 200 miles of line through a fairly rough country, with heavy freight traffic, through and local, together with a few fast through express trains and a moderate amount of local passenger traffic. It is a single track road, like most of its class, with occasional turnouts, and has some stiff grades and short tunnels. What information can the chief engineer find which actually bears upon his problem and how can he work out the change of motive power? The change must be made, if at all, with reference to conditions which in the main do not originate on the line. To begin with, take the passenger traffic. The express trains must take on at the ends of the line cars of the connecting divisions and the schedule must be regulated in accordance with exterior requirements. The single car service of a typical fast electric line would result only in tying up the freight trains more than ever, since the way must be kept clear for fast passenger service and each new train, whether of one car or many, introduces a new complication. Likewise the rather lean local passenger service cannot be increased by multiplying the car service until some way is devised for two trains to pass at will on a single track. Experiments on this scheme have heretofore always ended in disaster.

As to freight traffic, it must for economy be handled so far as local conditions allow in rather heavy trains, the nature of which is in the main determined by the foreign freight at the termini. Obviously questions of quick local service and gains from rapid acceleration drop out of sight at the start. If electrical locomotives are to be used they must conform in practical performance quite closely to the steam locomotives now in use. Not only this, but they must make provision for imposed conditions which have nothing to do with the local problem. For instance, each of the through express trains takes on a couple of foreign Pullmans equipped with steam heat. The passengers cannot be allowed to freeze for five or six hours and it is quite impracticable to equip all the cars that may come that way with electric heaters. This is the very issue that early arose in the New York Central electrification and gets worse and worse as the electrification line grows longer. Incidentally all the tunnels and overhead bridges are so low as to make the safe installation of an overhead high-voltage trolley wire difficult and a couple of big rotaries in the year bear silent witness to the foolishness of trying the third rail. Now when the chief engineer is up against a concrete problem like this, he does not want to be told that the multiple unit system is a great thing to build up the suburban traffic which does not exist, or that our Type Z 4-11-44 locomotive will pull up a 6 per cent. grade at 30 miles per hour a freight train twice as heavy as any that under the existing schedule he can possibly manage on the line. He is friendly to electric traction and would be glad to see it adopted, but he wants somebody to get right down to business with him, study the actual conditions of service, and figure out how to make electrification pay. The average electrical engineer, however competent, has never had to deal with requirements of an intricate schedule imposed as one of the conditions of the problem by causes beyond his control, and hence has not always been able effectively to come to the rescue of the man who needs practical help.

Flexibility in Auxiliary Piping.

In the design of piping layouts for the supply of live steam to engines or turbines, flexibility of operation is usually secured by providing valves enough in the boiler and engine rooms to enable any engine unit or any boiler battery to be cut off without interfering with the rest of the system. Many installations go farther than this by employing two live-steam headers cross-connected at their ends, or possibly by using a partial or complete loop in the plant. However simple may be the piping scheme—and such layouts tend to avoid duplication in recent designs—it is rare to find the main boiler and engine units inadequately valved. This cannot always be said of the auxiliaries.

It is quite as important that provision should be made to cut off any auxiliary without interfering with the rest of the plant as that the main header should be flexibly arranged. A plant recently examined illustrated this point only too well. The boiler-feed pumps, the circulating pumps, and several other auxiliaries were supplied with steam from an auxiliary boiler in the engine-room basement, parallel to the main steam header in the boiler-room. The two headers were cross-connected at their respective ends, which gave a flexible and inexpensive method of operation in times of emergency. Unfortunately, however, the minor piping was so arranged that the branch supplying the feed pumps could not be shut down without shutting down the entire plant, and the same thing applied to the steam-driven centrifugal pumps of the condenser system. On both these branch lines bad leaks were hissing at the time of the visit, and the chief engineer had not been able to shut down the plant a single hour for many weeks to make the necessary repairs.

If the feed pumps and circulating pumps had each been supplied with steam from the auxiliary header by a separate short line to each pump, with a valve in each lead near the header as well as at the pumps, the repairs could have been made in short order without the slightest interruption of the service. Failure to appreciate these points costs the plant excessive fuel consumption and hazards the continuity of the service. The cost of feeding each auxiliary separately in this case could be very moderate, as only small pipes 2 or 3 in. in diameter would have to be run a maximum distance of 20 or 30 ft. Auxiliary by-passes and independent connections are relatively inexpensive and, on the whole, easily installed, even in a crowded plant.

Industrial Engineering.

Industrial engineering or mill architecture, to use an older term meaning the same thing, is a subject of unusual interest although it rarely receives much attention in print. For this reason the excellent paper on the "Arrangement of Railroad Shops," prepared by Mr. George A. Damon, for the Canadian Railway Club, and printed elsewhere in this issue, deserves special comment. It is sometimes said that the mill architect has little to do beyond designing buildings and laying out power plants, but the error of this view is indicated by the paper mentioned. It takes but a brief experience in the office of such a specialist to learn that the vital part of the work is done before any steelwork is taken up and any power plant is considered. The success or failure of the shops will not depend on the design of the beams and trusses nor on the power plant nor system of power transmission, but on the cost of the product of the works. This low production cost depends on the working conditions and the main problem of the mill architect is to make these conditions as favorable as possible.

Two mills not far apart may be cited to explain what is meant. One of them is a rough affair which, to the average visitor, is so shabby as to indicate pretty hard sledding for its owners. It is running more weeks in the year than any of its competitors in the same district, however, and its cost of production is known to be the lowest in that section. Moreover, when the raw materials on which it depends are exhausted, the plant will be about worn out and the loss on account of investment sunk in buildings and equipment will be relatively slight. In the same district there is another mill making the same product. Its imposing buildings have been illustrated in a prospectus issued to sell stock, each part of its equipment was designed by a specialist to be as economical as such equipment could be made, yet the plant as a whole was so expensive to run that it went into the hands of receivers and is a notorious white elephant because, when it was designed, attention was not paid to the industrial process as a whole, but was confined to each step or department. Probably every industrial engineer who reads these lines can recall comparisons of the same nature; attention is drawn to the subject because Mr. Damon emphasizes in his paper the importance of preliminary studies. In fact, it will be difficult to find in any other article such a clear exposition of the basic work of the mill architect.

Another feature of the paper which is particularly deserving of notice is the publication of statements of cost, something so unusual as to indicate a breadth of professional view on the part of the Arnold Company which is highly gratifying. It is time, indeed, for a revision of methods in engineering work of this nature. The old-fashioned way was to get an enterprise started under any circumstances and after the first plunge was made to break the financier's heart gradually with a mounting bill of costs. It is evident from the paper that the author's company does not follow that plan, but makes its struggle for a sufficient appropriation at the outset and then endeavors to please everybody by keeping the actual expenditures within the appropriation. The country is dotted with mills and factories closed down in whole or in part because they cost so much more than was anticipated that the work for which they were designed is unprofitable. When a man engages an architect to design a residence he knows from the experience of his friends that the building will cost most than the estimates, unless he is unusually lucky or the contractor does not live up to the specifications, but when he goes to an engineer for plans for a mill he expects something accurate and ought to get it, for the uncertain factors of the work are very few and of trifling importance.

Notes and Comments.

Wood Block Pavements are specially called to the attention of the Board of Aldermen of New York City in the annual message of Mayor McClellan, submitted to the Board this week. He had an opportunity last summer of looking into the wood pavements of Paris, where there is a large amount of such paving in use, and reached the conclusion that "the methods there is use, if employed here, would permit wide competition for contracts to lay wood block pavements, as against the present limited competition confined practically to owners of patented processes." These Parisian methods to which allusion is made depend upon the operation of a timber treating plant by the municipality, where wood blocks are made by city employes and old blocks from streets undergoing repair are redressed. In other words, the city furnishes whatever kind of blocks it prefers for a given street and their treatment and dressing are not left to private contractors. It is possible that this suggestion is made by the mayor as a result of the successful experience of the city with the repair plant for the asphalt pavements of the Borough of Brooklyn, although the two kinds of plant are not at all alike. The manufacture of wood paving blocks can be undertaken by the city, of course, but The Engineering Record is strongly of the opinion that it would be better policy to defer the construction of such works for the present and to concentrate attention on specifications for such pavements and on the rigid enforcement of them. A large amount of wood block pavement has already been laid and until its wear under the local New York conditions has been carefully studied it is hardly possible to tell just what specifications will give the best results, as was pointed out at much length by Mr. R. W. Creuzbaur, consulting engineer to the Borough of Brooklyn, in a letter printed in this journal on Nov. 30, 1907. The variations in the properties of timber of different species and grades and the results of different methods of treating each of them for paving purposes are very largely unsettled problems now.

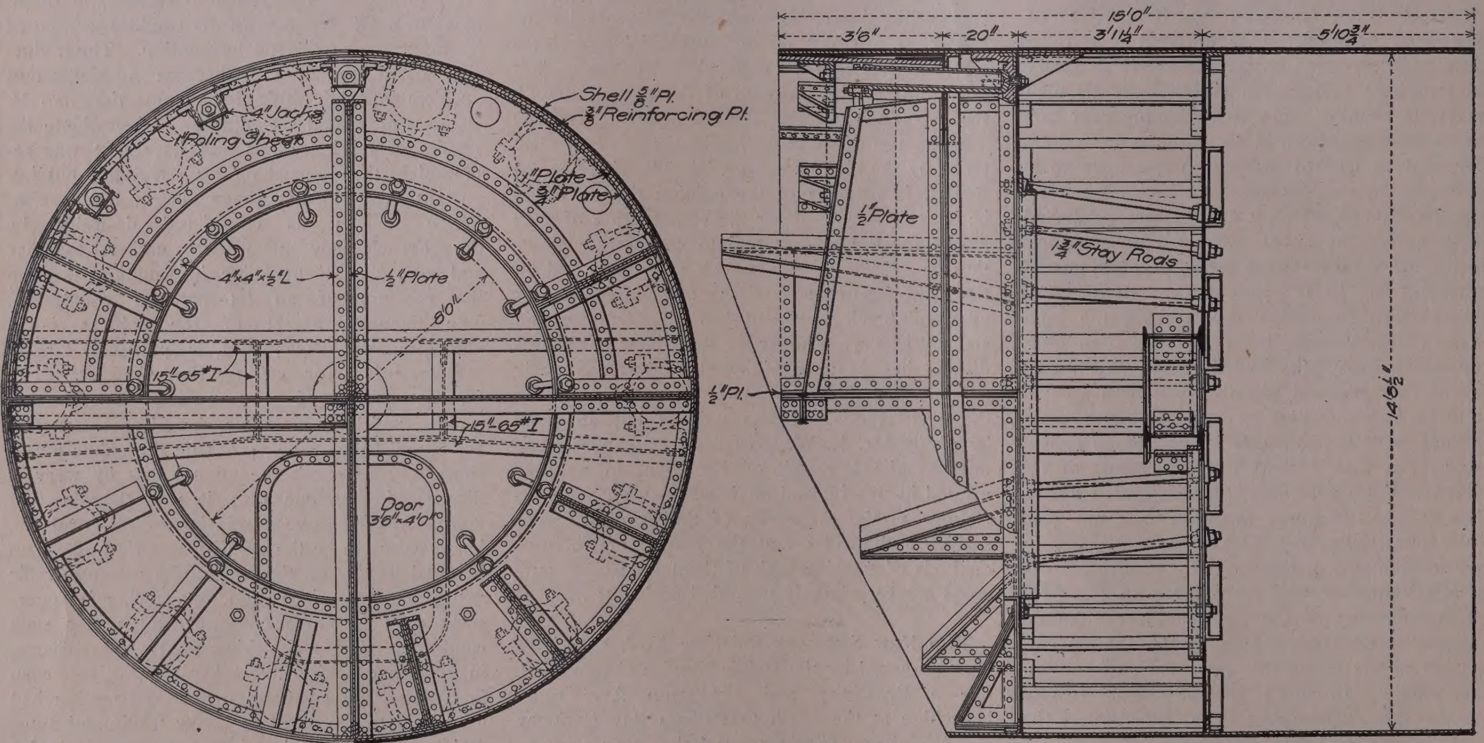
Two New Subways for New York City have been proposed by the Public Service Commission, one a Broadway and Lexington Ave. route branching at the north to Pelham Bay Parkway and Woodlawn Cemetery, and the other a cross-town line from the Manhattan bridge terminal to the North River by way of Canal St. Portions of the routes were laid out by the old Rapid Transit Railroad Commission, but in the new plans they have been joined together in a new way in order to afford relief for those sections that at present need better transportation facilities most. It has been stated so many times in these columns that such improvements are a crying need of Manhattan that it is unnecessary to go over the matter again, but there is one feature of the problem which deserves some notice. At the present time the city has no money to carry out this scheme and it will have to persuade the legislature to pass some special laws before it can finance such subways itself. Whether it is wise to take such a step is certainly a matter of debate, for with all kinds of necessary public service hampered by lack of funds the advisability of taking on a new burden that private capital might properly finance is an open question. As there is no immediate probability that the city will undertake the work and as the demand for better transportation is a weighty one, it might be well to try again to devise some method of private construction which will safeguard public rights and also prove attractive to capital. The manner in which such things are done in Boston is so admirable that it seems unfortunate the same thing looks so hopeless in New York. If the proposed subways were put under construction to-morrow they could not possibly be completed early enough to relieve the transportation situation which will then exist, and the delay in constructing them will result in driving into New Jersey a host of people who prefer New York, but will take advantage of the facilities afforded by the North River tunnel system to escape from the intolerable conditions of rapid transit on Manhattan.

The International Congress for the Adaptation of Roads to Modern Traffic will be held the latter part of the current year at Paris, and the French Minister of Foreign Affairs will shortly issue invitations to other nations to be represented at this gathering. M. Barthou, Minister of Public Works, presided on Dec. 13 over the first meeting of the committee which he had appointed to organize the Congress, and stated that its object was to discuss methods of adapting the public roads, the bad state of which threatened to become dangerous to traffic and disastrous to public finances, to the conditions imposed by modern methods of locomotion. The reduction of dust had also become an important problem in public sanitation. Some time ago M. Barthou appointed a committee to investigate the results of tarring roads and its report was reviewed in this journal on Aug. 17, 1907, but important experiments have been made elsewhere and it is considered desirable by the French government to gather together and compare all available information through the medium of an international conference. The financial aspect of the subject is a most important one, and is probably largely the incentive for calling the Congress. The famous roads of France are deteriorating rapidly, and their maintenance and reconstruction are bound to lay a heavy tax on the public unless some way to check the annual loss by wear is discovered. At one time it was thought that tarring would prove a solution of this problem, but it seems to be the opinion now that macadam has had its day on the roads with a heavy traffic and automobile circulation, for tarring is apparently only a temporary expedient under such conditions. It is astonishing what a great change in opinion on this subject has taken place, even in France. Five years ago a little attention had been paid to the effect of heavy traffic and automobiles on the roads of that country and also those of Great Britain, but a rather extended inquiry made by this journal among American engineers failed to discover more than a single case of injury that was positively assigned to this cause. Now some of the commissioners and engineers who ridiculed five years ago the suggestion of any special wear on highways from motor cars are most active in endeavoring to abate it, and are making examinations and keeping records which will be of much value if communicated to the International Congress for comparison with experiences elsewhere.

THE FLUSHING TUNNEL FOR THE GOWANUS CANAL IN BROOKLYN, N. Y.

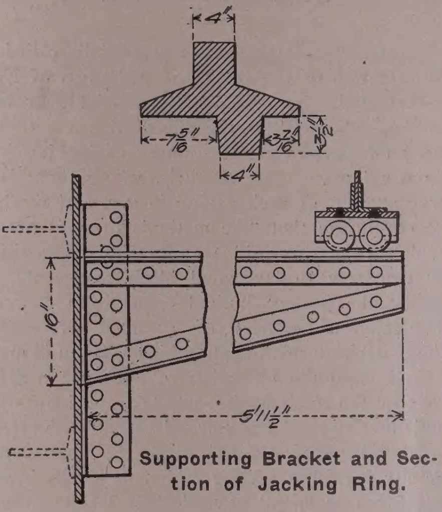
The Gowanus Canal is a dredged creek channel which leads in a general northerly direction from Gowanus Bay, on upper New York Bay, into Brooklyn, N. Y., a distance of about 1½ miles, coming to a dead end at Butler St. This canal efferds dock facilities for the manufacturing establishments and warehouses in the part of the city that it traverses, and in annual tonnage it ranks high among the waterways of the country. It is in general about 12 ft. deep and 100 ft. wide; there are several dredged basins and arms connecting with it that serve buildings not on the line of the main canal. The flow from a considerable number of sewers and the waste from a variety of manufacturing plants is discharged into the Gowanus Canal. There being no definite movement of the canal water other than that caused by tides, the condition of the canal has been for many years unsanitary in a continually increasing degree, and the odor arising therefrom has become very offensive for many blocks away from the canal. To relieve this condition a flushing tunnel is now being built, through which the water of the canal will be pumped westward about 6,270 ft. to an outlet into Buttermilk channel opposite the north end of Governor's Island. From the intake at the upper end of the canal the course of the tunnel is 1,000 ft. west in Butler St., 500 ft. south in Hoyt St., and 4,770 ft. west in Degraw St. to the outlet.

The tunnel is circular with an inside diameter of 12 ft., and is built of four rings of brick, 16 in. thick at all points. It is laid without fall, with the invert at El. —18.50, datum being mean high water. The material traversed is sand of varying fineness, ranging from good building sand to quicksand. At the outlet the natural surface is about at El.5 and at the intake the ground surface is about at El.10. From these points the ground rises gradually in both directions toward Court St., which crosses approximately the middle point in the length of the tunnel. Here the surface of the ground reaches a maximum elevation of about 46 ft. above mean high water, or 65 ft. above the invert of the tunnel.



Sections of Shield Used in Constructing the Tunnel for Flushing the Gowanus Canal, Brooklyn, N. Y.

The tunnel is being constructed from two headings, driven from a single shaft placed on the line of the tunnel about 300 ft. west of Court St. Compressed air at a pressure of about 7 lb. per square inch is required in both headings and the excavation is being carried forward by the shield method, but its particular application differs materially from that used in previous subaqueous tunneling with one or two exceptions. The character of the work is such as to require a large amount of special equipment for its economical handling. This special equipment has been designed by the contractor's engineer in charge of the work and some of the lighter apparatus has been built on the work. One marked departure from the usual custom is the substitution of electricity for steam as the motive power of the entire plant. This was made necessary by the limited space in the street which the contractor could occupy and the necessity for a plant which must be free from dirt and noise, such as would necessarily accompany a steam plant. Direct-current motors are used throughout for the operation of all machines such as hoists, pumps, air compressors and the like.



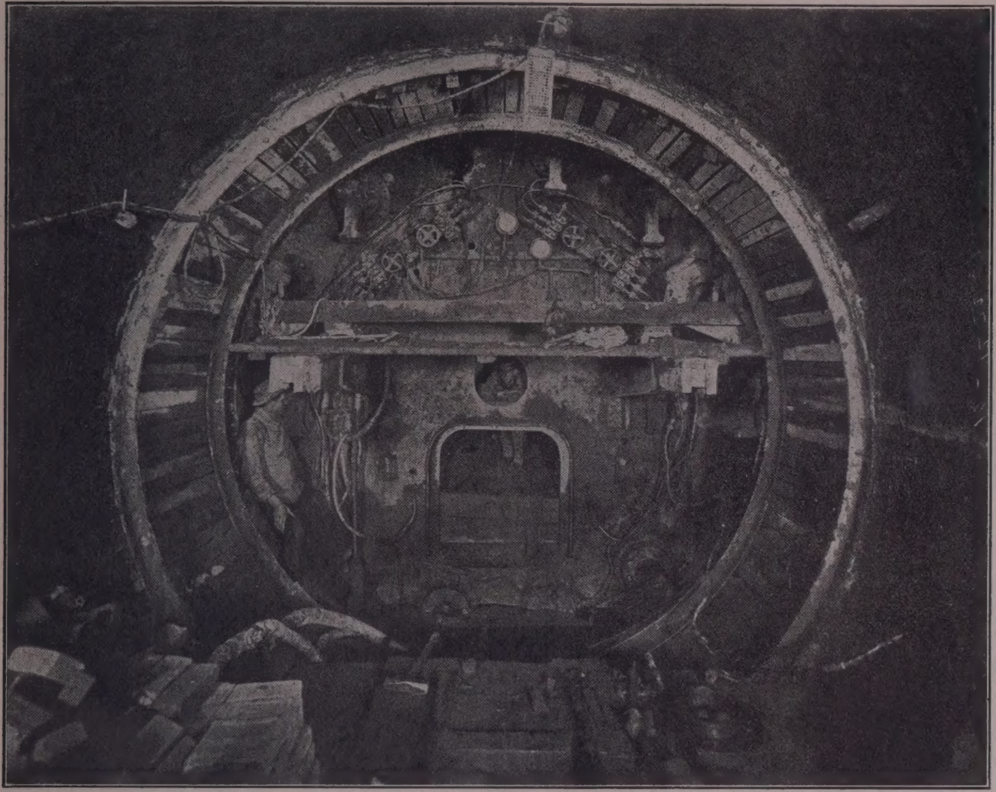
Supporting Bracket and Section of Jacking Ring.

Electricity for the entire operation is furnished by the Brooklyn Edison Co. It is brought to the work at 6,600 volts alternating current and there passed through static and rotary transformers of about 1,200-h.-p. capacity and transformed into direct current at 240 volts. There is also a direct low-tension cable to the Edison power station, so that in the event of accident to the rotaries about 300 h.-p. can be supplied from storage batteries through a booster in the Edison station.

The surface plant of the contractor comprises, in addition to the rotary station, an air compressing plant, with a nominal capacity of about 12,000 cu. ft. of free air per minute, the hydraulic pumps for shoving the shield, material sheds, a large elevated bin for the storage of excavated material, pipe shop with pipe cutting machine, a carpenter shop, head house over the shaft, wash house for the sand hogs and the superintendent's office. These buildings are of the temporary shed type, but are built well enough to afford ample protection for machinery and men during the winter.

The equipment of the transformer station comprises three 200-kw. Westinghouse and three 150-kw. General Electric static transformers, one Westinghouse 500-kw. and one General Electric 400-kw. rotary transformer, also a 2-panel high-tension and a 4-panel low-tension switchboard of black slate is provided, fully equipped with the necessary indicating instruments, automatic circuit breakers and the like.

The air compressing plant consists of six Ingersoll-Rand Imperial Type 10 compressors, with nominal capacities ranging from 1,500 to 3,000 cu. ft. of free air per minute, operated by belts from direct-current motors, with horse-powers varying from 100 to 150. To operate the compressing plant three day and three night attendants and one master mechanic are required. The air from the compressors is led through two 10-in. mains to a 2,000-h.-p. Wheeler steam condensor, in which it is cooled, the circulating water being forced through the condensor by gravity from a 10,000-gal. elevated wooden tank supplied with water pumped from the tunnel. The waste water from the condensor is discharged into a sewer basin nearby. Two 10-in, air lines are placed in the shaft and two 8-in. lines of spiral-riveted flanged pipes in 20-ft. lengths lead into each heading. Owing to the limited space in which to install the plant and the low pressure of air used, it was decided to operate the compressors at about 25 per cent. beyond the normal speed. This has been done without heating or appreciably effecting their economy.



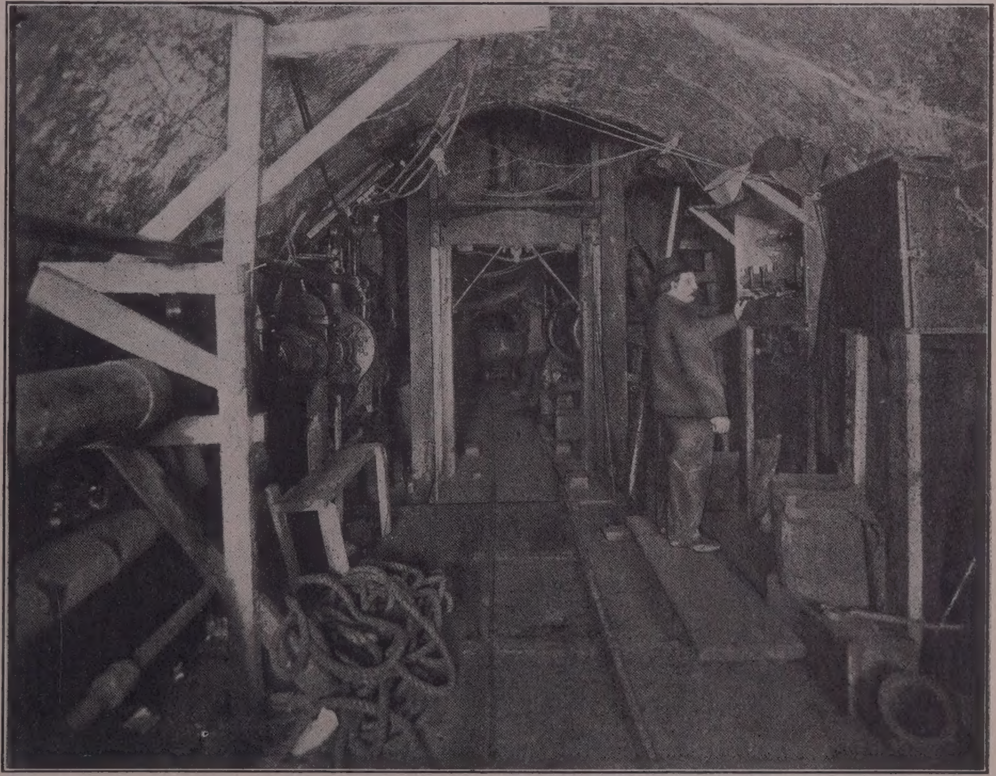
Shield in Brooklyn Flushing Tunnel, Showing Lagging and Rings in Place.

A Watson-Stillman double-acting double-cylinder hydraulic pump is installed in the compressor building for operating the shield jacks. This pump is driven by a 60-h.-p. Westinghouse motor. A second high-pressure pumping unit similar to the one described is held in reserve for emergency use.

The bin for excavated material is about 45 x 20 ft. in plan and is carried on three longitudinal lines of timber posts, which form two driveways under the bin. In one of these a track is laid connecting with the B. R. T. system, on which gondola cars of the type used by the Brooklyn Rapid Transit railway can be operated. The spoil is hoisted through the shaft in dump cars, which are run off the cage and out over the top of the bin on elevated track and dumped, to be delivered to wagons or cars below. Some of the excavated sand has been sold for building purposes, but the greater part is hauled away in cars and wasted.

Brick and cement are delivered in wagons and stored to the west of the shaft alongside a track on which the regular tunnel cars are operated. In order to avoid blocking Degraw St. only a single day's supply of brick and two days' supply of cement are kept on hand. The shaft cage is operated by a 40-h.-p. Lidgerwood electric hoist.

The shaft is 18 ft. square inside, a large shaft being necessary to admit the assembling of the shields. A heavy timber caisson was first sunk under pneumatic pressure to the required depth and its bottom sealed with concrete. The deck of the caisson was then removed, it having been built so that this could be readily accomplished, and the shield for the east heading was assembled at its proper line and elevation at the bottom of the shaft. The deck of the caisson was then replaced and made tight, the air was put on, and the shield was started and driven far enough to give room behind it for the erection of an air lock. The deck for the caisson was then again removed and the shield for the west heading was assembled. The deck was again replaced and calked and the air was put on until the second shield and air lock were in place. The deck was then finally removed and work was begun simultaneously in both headings.



Hoist at Foot of Shaft, Showing Signal Box and Pumps beyond Hoist.

Each shield is 15 ft. long and 14 ft. 8½ in. in diameter inside and weighs with its jacks, piping and other equipment about 55 tons. The length of these shields is somewhat more than is common in tunnels of approximately the same diameter. The design corresponds in general features to that of other cylindrical steel shields used for previous tunnel work, but is different in some details. The shield is made of two plates, the outside one being ⅝ in. thick and the inside one ⅜ in thick. About 9 ft. back of the upper part of the cutting edge is a vertical transverse diaphragm of ¾-in. plate, with a 4 x 3½-ft. door opening near the bottom. In front of this diaphragm and 3 ft. 11¼ in. from it is an annular girder about 36 in. deep, made up of a ¾-in. plate and angles, as shown in accompanying illustration. This ring is an important part of the bracing system of the shield; to its front face are attached, with riveted connections, triangular brackets of plates and angles, which are also attached to the shell. Leading back from the inner edge of the annular ring to the diaphragm are twelve 1¾-in. stay rods, the attachments of which at both ends are made adjustable by the use of two nuts, one on each side of the plate.

The rear end of the shield projects 5 ft. 10¾ in. behind the diaphragm to form a tail piece, inside which the brickwork of the tunnel is built. In front of the stiffener girder the shield is divided into four equal compartments by a vertical and a horizontal plate ½ in. thick, both of which extend forward practically to the cutting edge. A 3-ft. hood or poling sheet was built to be used with each shield, but difficulty was experienced in sustaining these, and they have been abandoned. The shield is equipped with fourteen 140-ton Watson-Stillman jacks, with automatic drawbacks, placed symmetrically about the inside of the shield in the space between the annular stiffener girder and the diaphragm. These jacks have 8½-in. pistons, with a 36-in. stroke and are provided with heavy cast-steel hinge extension pieces, with legs of unequal length, permitting of an extra shove of the shield of about 10 in., by first using the short leg and then the long one. Experience has shown, however, that there is considerable difficulty in sustaining the working face when the shield is shoved the maximum distance, and better progress is made without the use of the long leg of the piston extension. In general, the maximum pressure used in operating the jacks is about 3,500 lbs. per square inch. After the shields were brought on the work their form was altered slightly by bringing the lower part of the cutting edge forward till it is nearly in the same plane as the upper part and by cutting off the projecting ends of the braces designed to support the poling sheet, shown in the illustration.

The jacks react against a very heavy cast-steel ring, which covers the entire face of the newly finished brickwork, and distributes the pressure over it. The ring has cast upon its face, projections which fit the toothing in the brickwork. This ring, which weighs about 3½ tons, has riveted across it horizontally, somewhat above its horizontal diameter, a steel beam, to which are fixed two sets of steel rollers of the form shown in the drawing. To the rear face of the diaphragm are bolted two heavy brackets made up of angles and plates and extending 5 ft. 11½ in. to the rear of the diaphragm. The top of each of these brackets has a face plate 8 in. wide attached with countersunk rivets, on which the rollers carrying the weight of the cast-steel jacking ring operate. The ring is attached to the rams of four of the jacks, and when these jacks are drawn back after making the shove they carry the ring with them. The ring not only forms a toothing, but is used as a profile also by the bricklayers.

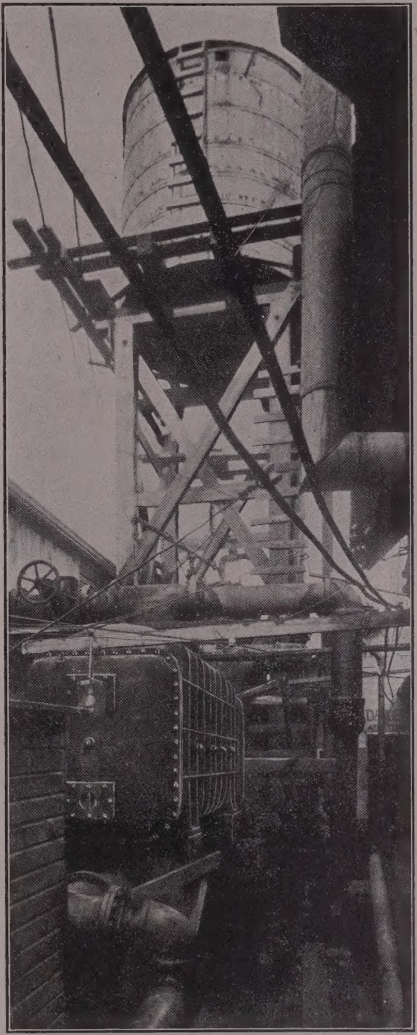
When a shove is in progress the breast is supported by breast boards, braced by two timber shores fitted with screw jacks, which react against a transverse timber laid against the cast-steel jacking ring. Clay is freely used in mudding the working face to prevent excessive leaking of air. Each shield is operated by a gang of 19 men, made up of one foreman, four miners and 14 ordinary laborers. The work is carried on continuously night and day, there being three 8-hour shifts in 24 hours. Eleven feet is the average progress of each shield every 24 hours, but as much as 15 ft. is frequently made in the same time.

The centering differs materially from that commonly used in that the lagging and the ribs are not fastened to each other. The ribs consist of four segments of two 3 x 4-in. angle irons riveted together so that each angle projects 1 ft. beyond the other on opposite ends to allow for joining the segments together. The ribs are circular, and both ribs and lagging go all the way round. The bricklayers lay the lagging up to the springing line as fast as they lay the brick, and this protects the green brickwork from damage due to walking upon it. When the springing line is reached the laborers set the rib, which takes about 10 minutes, then the bricklayers proceed with the brickwork, dropping in the lagging for the arch as the brickwork proceeds. The usual time required for two bricklayers to complete a 34-in. ring of brickwork is 4½ hours. In the meanwhile the excavation is made and the shove is usually started within 15 minutes after the completion of a ring of brickwork and finished within another fifteen minutes, after which the bricklayers start at once on a new section.

While the brickwork is being laid the hydraulic pipe, the platform and the spoil track is extended, and also the electric cables, so that every operation is completed within itself. No time is lost moving locks, as they are moved on Sundays, when no other work is going on.

The bricks are laid up in a mixture of Atlas Portland cement, consisting of two parts of sand and one of cement, using sand excavated in the tunnel. As soon as the centering is struck on a section of brickwork it is promptly covered with a neat cement wash, and as soon as this has set a coat of special red paint known as "cement skin paint" is applied. These measures prevent excessive loss of air until the space left by the shield back of the brickwork can be grouted.

At about 9 ft. intervals 2-in. grout pipes are built in the masonry in sets of three and five, alternately. The grouting is kept as close as practicable to the shield; thin grout with one part of sand to one part of Trowel Brand cement is used. This is forced through the pipes at a pressure of about 30 to 50 lbs. per square inch by a special 2-stage 2-in. centrifugal sand pump made by the Morris Machine Works. The pump is operated through a direct connection by a 30-h.-p. power Westinghouse motor, and the two are mounted on a low flat car, which operates on the same track as the material and spoil cars. The mixer consists of a steel cylinder about 6 ft. long, with a diameter of 2½ ft., through which extends an axial shaft carrying four flat paddle blades. These are placed parallel to the axis of the cylinder, so close to the inside surface of the shell as to keep it fairly clean and prevent the accumulation of a crust of cement. The paddle shaft is operated through a triple reduction gearing by a 6½-h.-p. Westinghouse motor placed at one end of the cylinder and covered with an extension of the cylinder shell. The mixer and its motor are mounted on a flat car, which is coupled to the pump car when the apparatus is in use. The cars and machines are designed to pass through the air locks without any dismantling other than removing the mixer hopper, which is made so that this can be readily done. The mixer holds about two barrels of cement, with a like amount of sand and enough water to make the mixture fluid. The general practice is to have the mixer full and then start the pump, and keep adding to the mixer as fast as the pump takes it. One gang of men, consisting of four men and a foreman, do all the grouting in both headings in 8 hours. A second grouting outfit is now being built to avoid the necessity of transferring the present apparatus from one heading to the other.



Elevated Tank and Air Cooler.

The excavated sand and materials of construction are handled to and from the shaft in each heading over 20-in. Koppel track laid on a plank deck placed about 2 ft. above the sewer invert and carried by transverse timbers about every 5 ft. The cars, which are of the turn-table front dump type, were especially designed to be operated through the air locks with a minimum clearance and a maximum capacity and to take turn-out curves with a 12-ft. radius without difficulty. Up to the present time these cars have been operated by hand, but an electric locomotive is now being constructed on the work for handling them.

This locomotive consists of a 15-h.-p. direct-current motor mounted on a low flat car and equipped with a series of chains and sprockets, one of which, mounted on the rear axle of the car, transmits the power from the motor to the rear wheels; an additional pair of sprockets and a chain on the opposite side of the car drives the front axle. The trolley consists of a four-wheel carriage, which runs on the two wires of the power circuit and is connected to the motor by a flexible insulated cable. The trolley wires are carried on the two arms of an inverted T-bracket, and the framework of the carriage is U-shaped and encloses the T-brackets, its two sides being separated by special insulators.

The air locks first installed were of the ordinary riveted type, but those now in use have bolted connections, so that the lock in the rear can be advanced by dismantling it and carrying its sections through the forward lock. The locks are set in brick bulkheads, and the maximum distance which the shield is advanced before the locks are moved up is about 300 ft.

Seepage water is collected in a sump at the bottom of the shaft, from which it is pumped to the surface and to the elevated tank before mentioned by two sets of compound Morris Machine Works centrifugal pumps operated by Westinghouse motors. One of these sets is placed in the tunnel near the shaft and has 4-in. suction and discharge pipes. The other is mounted about 15 ft. above the bottom of the shaft on a part of the deck of the shaft caisson; this set has 6-in. suction and discharge pipes. The cage at the shaft is operated with unusual care, a special system of electric lamp signals being provided for signalling the engineer from the bottom. The lamps are colored and plainly marked, and two are provided for each signal both in the engine room and at the bottom of the shaft to avoid accidents, which might result through the breaking of a lamp filament if only one signal lamp was used. In order to avoid accident by lowering down on some one who might be underneath it, the cage is always stopped 10 ft. above the bottom of the shaft and held until the man at the bottom signals to lower. A complete telephone system is maintained on the work, with a switchboard in the superintendent's office and instruments in each heading, at the foot of shaft and in the power plant.

The plans for the pumping plant and the building to shelter it are well under way, and it is hoped that contracts may be let early in the spring. The pumping plant will consist of a 14-ft. turbine-type pump, direct-connected to a triple-expansion condensing engine of approximately 350 h.-p., which will be placed in a pit at the side of the tunnel intake at such an elevation that the main shaft, which will be horizontal, will be on a level with the springing line of the arch of the tunnel.

The general arrangement of machinery will be somewhat similar to that for the two Milwaukee flushing tunnels, described in The Engineering Record of July 27, 1907, though in details of design it will differ from the Milwaukee plants. The rate of pumpage from the canal into the East River will be determined after the plant is in operation. The building will be arranged so that coal may be unloaded into it directly from barges in the canal.

The flushing tunnel is being constructed under the direction of the Bureau of Sewers of the Borough of Brooklyn, Mr. Edwin J. Fort, chief engineer; Mr. Arthur S. Griffin, engineer of construction; Mr. W. S. Moore, assistant engineer in charge. The John Peirce Co., of New York, whose bid for the tunnel was $100 per lineal foot, is the contractor. Mr. E. C. Moore, engineer and superintendent in charge for the contractor, designed the shields, the electric locomotives and other special apparatus described. The shields were made by the D. Connelly Boiler Co., Cleveland, Ohio. Six hundred working days are allowed for the completion of the tunnel and about 30 per cent. of the work has been finished. Work on the intake is well advanced, but the contracts for the pumping plant have not yet been awarded.

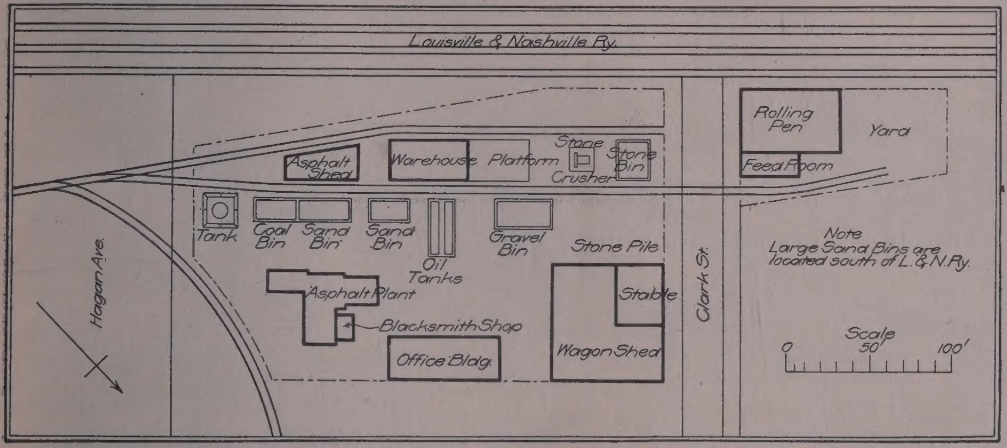
An Electrically-Operated Pumping Plant.

An electrically-operated pumping plant supplies the South Tacoma section of Tacoma, Wash., with water from eleven 150-ft. wells, 7 to 12 in. in diameter. The total flow is 5,000,000 gal. per day and the total head pumped against is about 160 ft. The water is delivered into two distributing systems, the high-level and the low-level. The water for the low-level system is delivered by the pumps into a flume situated at the station, through which it flows by gravity to the low-level reservoir. The pumping is done by an air-tight system. The air compressor equipment consists of one 150-h.-p., 2,300-volt, two-phase Westinghouse induction motor belted to a horizontal two-cylinder Ingersoll-Rand compressor; and two 75-h.-p., 2,300-volt, two-phase Westinghouse induction motors, each belted to a 75-h.-p. horizontal, two-cylinder Ingersoll-Sargent compressor. The air is compressed to 210 lb. per square inch. For pumping into the high-level mains there are two 150-h.-p. motors each belted to a vertical, triplex, 12x14-in. Gould pump. Each of these pumps furnishes 2,000,000 gal. per 24 hours against a 200 ft. head. The pumping plant is owned by the city and the current is supplied by the Snoqualmie Falls Power Co. at 23,750 volts, which is stepped down to 2,300 volts by four 180-kw., two-phase, four-wire General Electric transformers. The cost of maintenance and operation is said to be considerably below that of an equivalent steam plant. One man on each shift operates the plant and has but little to do except to keep awake. A corresponding steam plant would require at least three men on each shift and a little over double the present wage expense. The pumping load is considered very desirable by the power company which took the contract at the very low rate of one cent per kilowatt-hour with the understanding, however, that within a few months the rate would be raised to 1¼ cents per kilowatt-hour.

A Municipal Repair Plant for Pavements, New Orleans, La.

A few weeks ago this journal called attention in a brief note to the good showing made by the municipal repair plant at New Orleans during the past year. From the report on this plant and its operations recently made by Mr. W. J. Hardee, city engineer, the following details have been taken, in order to show just what is being done there. The plant was constructed to insure a better maintenance of asphalt pavements, but its field of usefulness has gradually been extended so that now it is equipped to repair other kinds of pavement and also to grade earth streets and surface them with crushed stone or similar material.

The plant is located on a piece of city property, approximately 175 x 260 ft., and is very favorably situated, being in immediate proximity to the New Basin canal, which minimizes the cost of delivery of sand, gravel and shells; moreover, all parts of the city are accessible from the plant over paved streets without considerable detour and with an average minimum haul; and there were two railway switch tracks already in place. In this yard are the asphalt repair plant, a blacksmith shop, a 24 x 68-ft. two-story office and laboratory building, a large stable and wagon shed, a 24 x 46-ft. one-story warehouse, a 1,300-gal. elevated galvanized iron water tank, a stone crusher with storage bins for crushed stone, an asphalt shed and bins for sand, gravel and coal and two 6,000-gal. cylindrical steel tanks for storing fluxing oil. The general arrangement of the plant and its position relative to the switch tracks and the canal is shown in an accompanying illustration.



Plan of Municipal Repair Yards at New Orleans.

The asphalt plant is housed in a substantial building of brick and concrete, covering about 1,500 sq. ft. The boiler and engine section is one story high; the dryer section and the asphalt melting tank section are each two stories high; and the central or tower section, containing the sand bin, mineral dust bin and the mixer, is three stories, or 32 ft., high. The boiler, engines, dryer and melting tanks have substantial concrete foundations independent of the foundations of the building. The hot sand and stone bin and mixer, together with their auxiliary apparatus, are carried on a four-leg steel tower erected within the building and resting on independent pier foundations of concrete. The building foundations and walls thus carry only the weight of the floors and roof.

The boiler and engine are of the undermounted portable type, rated at 35 h.-p., and were manufactured by the Erie Engine Works, Erie, Pa. The boiler is designed to operate at 100-lb. working pressure and the engine is of the center-crank type, with a 10 x 15-in. cylinder. Compressed air for agitating the asphalt in the melting tanks and for forcing the fluxing oil from the storage tanks to the flux weighing tank is supplied by a 9½ x 13-in. Westinghouse compressor having a capacity of 50 cu. ft. of free air per minute. The compressor is driven with steam from the main boiler.

The dryer is of the self-contained type, manufactured by the Warren Bros. Asphalt Paving Co., contractors for the asphalt plant. It has a revolving cylinder 40 in. in diameter, 19 ft. 6 in. long, and the brick furnace underneath affords 19 sq. ft. of heating surface. Draft is induced by a 40-in. Sturtevant steel plate exhauster, which is equipped with a dust collector. At the receiving end the dryer is equipped with an endless chain bucket conveyor operating on a 45-deg. incline, the lower end of which is on the yard pavement about 10 ft. outside the building. At the discharging end the dryer is equipped with a similar conveyor, which delivers the hot material to the bin in the tower section of the building. The screen room on the third floor of the tower section is made with tight-fitting joints to prevent the escape of dust and heat; the screen is 2 ft. in diameter and 3 ft. long and is formed of No. 8 wire cloth made of No. 18 bronze wire.

The conical storage bin has a total capacity of 10 cu. yd. and is provided with compartments for different sizes of material. It delivers directly into the measuring box, which has a capacity of 9 cu. ft., and is placed immediately behind the mixer. This box is equipped with a dumping bottom to facilitate discharge into the mixer and rests on platform scales. In addition to the main storage bin, a small bin is installed in the top of the tower for the storage of mineral dust. An endless bucket conveyor is provided outside the building to convey the dust from the collector to this bin, and a chute is used for transferring the dust from the bin to the mixer.

There are two 6,000-gal. fluxing oil tanks, each 6 ft. 6 in. in diameter and 25 ft. long, made of 5-16-in. steel plates. Each tank is equipped with steam heating coils, a compressed air connection and a safety valve set to blow off at 10-lb. pressure to relieve excessive pressure which might arise in the tank due to the volatile nature of the oil. To minimize fire risks as well as to improve the facilities for charging the tanks, they are placed about 30 ft. from the plant building and within 8ft. of the nearest switch track. The oil is delivered in tank cars and is discharged by gravity into the storage tanks, which are placed in a vault with concrete foundations and floor and brick walls extending 18 in. above the yard pavement and roofed with a light timber structure.

Each of the three asphalt melting tanks measures approximately 108 x 60 x 52 in. and has a capacity of about 5,000 gal. These tanks are made of 5-16-in. steel plates and are set in brick masonry casings, the tops of the tanks being level with the second-story floor of the building. Under each tank is an individual brick furnace designed to burn coal, and in each tank are compressed air pipes, this being used to agitate the melting material.

After the plant was completed the results of certain tests led to the changing of the method of applying heat in the melting tanks, steam coils being installed, to be used instead of direct heat from the furnaces. It was found that the Maltha brand of California refined asphalt which the city had contracted to purchase would readily fluidize at a temperature of 110 deg. Fahr. in about six hours. To operate the tanks by direct fires would require a fireman for the three melting furnaces, in addition to the engineer and fireman for the main boiler and engine. The installation of steam coils saves the wages of day and night firemen for the melting tanks and also a considerable amount of fuel, since the operation of the air compressor and the steam coils from the main boiler would not require anywhere near as much coal as would be consumed by operating the main boiler and in addition the three melting furnaces. Moreover, the use of steam coils considerably lessens the fire risk in case the tanks boil over, as sometimes occurs. The melted asphaltic cement is transferred from the melting tanks to the weighing bucket by compressed air, thus doing away with the usual overhead trolley tracks and hand dipping of the cement. The weighing bucket remains permanently at the mixer, and the mixer attendant operates the valves, and the wages of a dipper man are thus saved.

The mixer is of the ordinary type used for such service and is capable of mixing 1,000 lb. of wearing surface, or 1,200 lb. of binder, per batch. It is placed on the second floor of the tower section, with its discharge chute 7 ft. above the driveway on the ground floor.

The stone crusher is a Reliance machine, with four sets of toggles for producing six different sizes. It is driven by a Westinghouse 20-h.-p. induction motor, which also drives an endless chain bucket conveyor for lifting the crushed stone 24 ft. into a storage bin above. This motor also drives some of the blacksmith's apparatus and a rattler for testing paving bricks. The storage bin has a capacity of 65 cu. yd., and is arranged so that material can be discharged directly into wagons below through two 12 x 12-in. valve gates.

In addition to the permanent plant, the equipment also includes seventeen mules and three horses, ten Watson 2-yd. asphalt dump wagons, eight 1-yd. dump carts, a full set of tools for use about the plant, one Universal 8-ton. steam asphalt roller, one Universal 2½ ton steam asphalt roller, one 7-ton Pioneer steam road roller, one Champion road grading machine, plows, scrapers, miscellaneous tools and office and laboratory equipment.

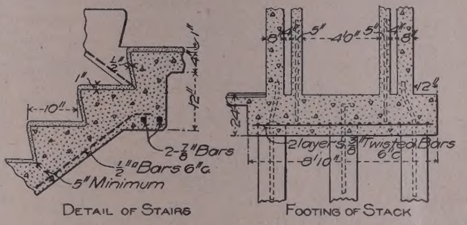
Before the municipal plant was completed contracts were entered into for supplying certain materials for one year at the following prices: Lake shore sand in large lots, moored at the power plant landing, 90 cents per cubic yard; Tchefuncta River sand, under the same conditions of delivery, $1.50 per cubic yard; pulverized limestone, purchased in the open market, under the same conditions of delivery, $5.50 per ton; washed river gravel on board cars at the repair plant, $2.27 per cubic yard; coal on board cars at the repair plant, $2.75 per ton; refined asphalt on board cars at the municipal repair plant, $18.50 per net ton.

The municipal repair plant was put in operation in the fall of 1906, and between Sept. 1 of that year and Aug. 31, 1907, 352,302 sq. yd. of asphalt pavement was cared for, that being the yardage on which the contract maintenance had expired up to Sept. 1, 1906. The total cost of this work was $40,306.83, or an average of 11.44 cents per square yard, and some of the total quantities involved were 8,024 cu. ft. of concrete, 23,682 sq. yd. naphtha coat and 35,905 sq. yd. of asphalt wearing surface mixture. Before the repair plant was contracted for bids were asked for repairing the same pavements. The lowest bid was that of the Barber Asphalt Co., which offered to do the work for a three-year period for $194,500, payments being $114,500 the first year and $40,000 the second year and $40,000 the third year. The saving effected by the plant for the first year was therefore almost $74,000.

The total cost of the repair plant was $66,008.82, the cost being itemized as follows: Asphalt plant, $19,599.12; stone crusher and storage bin, $1,966.20; stable, rolling pen and wagon shed, $5,310.93; office and store room building, $5,509.26; bins, sheds, warehouse, switch tracks, blacksmith shop, tower tank and filter, and miscellaneous yard improvements, $33,623.31; equipment, including livestock, rolling stock, tools and furniture, $17,643.45. The total cost of the plant was thus about $8,000 less than the saving made during the first year.

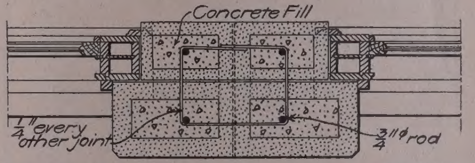
The payroll of the permanent force maintained during the year, including superintendent, office force, enginemen and firemen, foremen, hostler, blacksmith and watchmen, amounted to $20,040. This does not include the constantly varying charge for laborers, extra assistant foremen and the like.

Besides repair work, new asphalt pavements were constructed during the year requiring 36,707 cu. ft. of concrete, 8,369 sq. yd. of naphtha coat and 8,369 sq. yd. of wearing surface mixture, as well as catch basins, curb and gutter and all such appurtenances and grading, for a total actual cost of $20,941.72. These pavements would have cost considerably more if the aggregate used in the foundation concrete had been bought. Instead of purchasing crushed stone, uncrushed stone and old vitrified paving brick were run through the crusher, which produced during the year 1,143 cu. yd. of such aggregate at a cost of 46.66 cents per yard. If this had not been done it would have been necessary, according to Mr. Hardee, to buy river gravel at $2.27 per cubic yard, so that the crusher more than saved its cost during the year.



DETAIL OF STAIRS FOOTING OF STACK

Details of Stairs and Stack Footing.



Concrete Block Columns in Laundry Building.

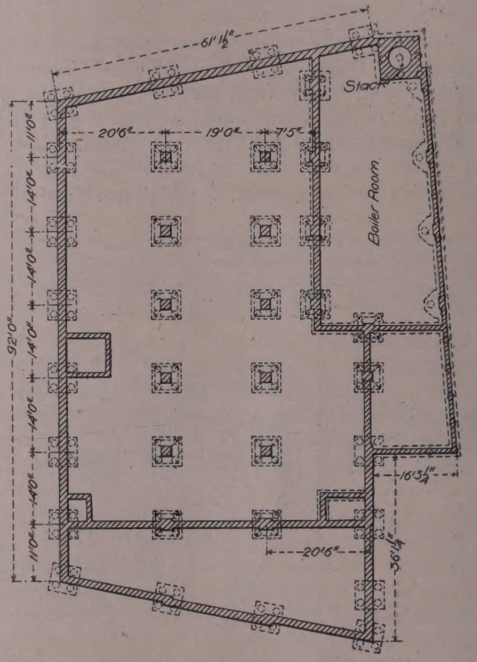
In all instances naphtha coat instead of so-called binder course was used in repairing old and building new asphalt pavement. Mr. Hardee believes that a naphtha coat formed of vaporized gasoline and asphalt mixed in equal proportions is very much superior to a binder made of gravel and asphaltic cement, such as is commonly used in New Orleans, gravel being the only readily available aggregate of reasonable cost there. Experience has shown, according to Mr. Hardee, that within three to five years the cement is dissipated, leaving the gravel a dry and inadhesive mass. The naphtha coat is put on the concrete foundation when the latter is dry, by hand with brushes just as paint would be applied. The coat is kept as thin as possible. It is practically impervious to moisture and prevents the moisture in the concrete from rotting the base of the asphalt wearing course.

In addition to the asphalt repair and construction work done during the first year, the plant was called upon to do a considerable amount of other miscellaneous work, such as grading earth streets and surfacing them with macadam material, setting curb and sidewalks, and repair work of various sorts. The total actual cost of this work was $20,983.76. The repair plant forces worked every day throughout the year, except Sundays, holidays and days when it rained. The asphalt plant worked 141 days and turned out altogether 88,947 cu. ft. of wearing surface mixture. The largest day's run was 1,845 cu. ft.

An All-Concrete Laundry Building.

A reinforced concrete laundry building having exterior walls built of a combination of concrete blocks and of concrete cast in place, and with a number of particularly interesting details in reinforcement, has been built in Salem, Mass., for G. L. Hooper & Son, proprietors of The Salem Laundry. The structure is four stories high, has a frontage of 60 ft. on Lafayette St. and extends in depth 100 ft. to Central St., with a one-story wing for the boiler and engine-room.

The building is situated on the site of an old dock, and the condition of the soil was such as to necessitate piling. Foundations supported upon wood piles cut off below tidewater were originally designed and estimated upon. It was found, however, that a considerable saving in the size of the concrete footings could be effected by the adoption of concrete piles, owing to it being unnecessary to cut them off as low in the ground, and they were therefore used. These piles are of the Raymond type and are 6 in. in diameter at the small end and have a uniform taper each side of the center of ½ in. to the foot, making a 21-ft. pile 20 in. diameter at the top. They have an average length of 20 ft. and carry a load of 25 tons each, taking the place of two wood piles in the original design. Obstacles in the form of old wharf timbers were met with in putting in the concrete piles, but the iron driving form used passed them without difficulty. Had wood piles been used serious difficulty, due to brooming, would probably have been experienced.

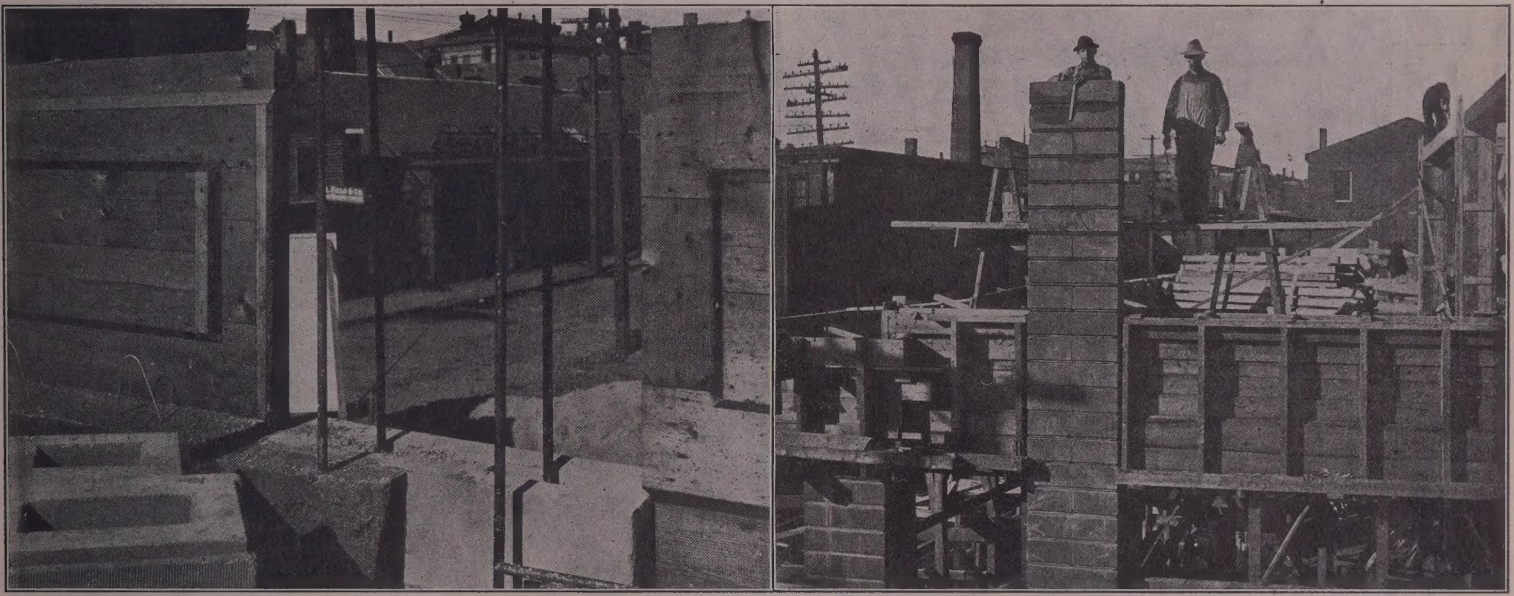


Foundation Plan of Laundry Building.

The general arrangement of the piles is in groups of four spaced 3 ft. center to center in the form of a square, each supporting a column or wall pier. Each group is capped with a concrete slab 5 ft. 6 in. square and 24 in. thick, making the projection of the capping beyond the center of the piles 15 in. Each pile was finished so as to allow a projection into the capping of 6 in. A group of nine piles supports the concrete chimney, 48 in. in diameter and 95 ft. high, each pile having rods imbedded in it, which project into the footing of the chimney so as to form an anchorage to the piles.

Between the groups of capped piles the bottom of the wall is reinforced with four horizontal ¾-in. twisted bars. The footing of the chimney is reinforced with a grid of ¾-in. twisted bars 6 in. on centers both ways, placed 6 in. from the bottom of the footing, or at the level of the tops of the piles.

The exterior walls are a combination of concrete blocks and monolithic concrete, the wall columns being built up of blocks, while the base course, the panels under the windows and the cornices, including the name and date inscriptions, are cast in position. The blocks are composed of what is known as "dry mixture," of 1 part cement and 3 parts sand, and were made near the building site as needed, being allowed to season ten days to two weeks before being placed in the walls. The blocks are of different sizes to suit the design, the longest of them being 2 ft. 8 in. They were made hollow, with molded vertical grooves on the exposed surfaces similar to "droved" stone work, rebates being made at the tops of each block so that recessed joints occur at each course when they are built in the wall. After being set in position these blocks bearing concentrated loads were reinforced with ¾-in. steel bars placed vertically inside the hollow spaces in the blocks and tied together at every third course with ¼-in. steel wire ties. The hollow spaces were then filled solid with a grout of 1 part cement and 3 parts sand.



Concrete Block Piers, Reinforcement and Forms, for The Salem Laundry Building.

For the monolithic portions of the building ordinary wood forms were used, the paneling, the ornamentation of the cornice and the inscription being formed by means of pieces nailed to the inside of the forms. The concrete in the monolithic base course is composed of 1 part cement, 2 parts sand and 4 parts broken stone, and the monolithic portions above were made a dry mix of the same materials and proportions as the blocks and were wetted or cured for several days after being molded.

The floor and roof construction are of monolithic concrete, carried by two rows of interior columns, which divide the building into three bays, running lengthwise of the structure. The columns are on approximately 20 ft. centers through the width of the building and on 14 ft. centers in the other direction.

The columns are 18 in. square in the first story, decreasing in size to 11 in. in the fourth story, and have corners chamfered 1½ in. Each column is reinforced with four ⅞-in. square twisted bars in the two lower stories and with four ¾-in. rods in the two upper stories, one rod being in each corner. They are placed 2 in. from the surface and are tied together every 12 in. with wire ties similar to the rods in the wall columns.

In addition to this reinforcement the columns of the two lower stories have reinforcement of round steel rods placed close together in the centers of the columns. Four of these core rods, 1⅜ in. in diameter, are used in the first and two in the second story.

Where the reinforcing rods for the columns bear upon the footings two ¾-in. wrought iron plates 18 in. square are provided, fastened in position with anchor bolts. The top plate is punched with holes of proper diameter and location to receive the column rods, keeping same in correct position, while the lower plate receives the thrust of the rods and transmits it to the concrete. Splices of the column rods occur at each story at the floor line, the rods being cut off true on the ends and encased in pipe sleeves, 10 in. long.

The beams and girders supporting the floors and roof are of rectangular section, with edges chamfered and are reinforced with plain round rods built into girder frames, according to the unit system. In the center of the span the reinforcing rods run parallel with and near the bottom of the beams and girders, and as they approach the supports half of them are bent up toward the top. The frames were securely fastened in position in the forms before the concrete was put in by means of special sockets bolted to the bottom of the forms and spaced 4 ft. apart. These sockets were left in the beams and girders for supporting pipes, shafting and other fixtures at any desired point on the ceiling, additional sockets being put in where desired.

Of special interest from an engineering standpoint are the heavy reinforced concrete girders over the boiler room. These girders are necessary by reason of the fact that the one-story boiler room extends for about one-half of its width beyond the walls of the main building, and it was desirable to avoid obstructing the floor space by columns. The girders have a clear span of 22 ft. and support the walls of the three upper stories near their centers. They are 20 x 30 in. and reinforced with twelve 1¼-in. twisted square rods at top and bottom.

Resting upon the floor beams and girders is a 4-in. flat concrete floor slab reinforced in one direction by ⅜-in. twisted square bars spaced on 6-in. centers and placed 1 in. from the bottom of the slab. At right angles to these are placed 5-16-in. square twisted shrinkage bars, spaced on 2-ft. centers. In the second story the slab for two-thirds of the floor is 5 in. thick and the reinforcement placed 4 in. center to center for supporting the specially heavy laundry machinery which is to be located in that portion of the building. This portion of the floor is designed for a floor load of 300 lb. per square foot. The remainder of the second floor and the floors in the other stories are designed for loads of 150 lb. per square foot. Varying conditions in the building have necessitated the use of several kinds of flooring. On the top of the concrete floor slab, except in special instances, tongued and grooved maple flooring is laid upon 2 x 3-in. wood sleepers spaced 12-in. centers, the sleepers resting upon the top of the floor slab and being filled in between level with their tops, with a cinder concrete composed of 1 part cement, 3 parts sand and 7 parts clean cinders. At 3 ft. intervals 30d nails are driven into the sleepers and allowed to project into the concrete to hold the sleepers rigidly in position. Where the wood flooring occurs directly over the ground on the first floor precautions have been taken to prevent the moisture from penetrating to the wood flooring and causing decay by placing a 3-in. layer of concrete underneath the flooring covered with a thick coating of pitch, and also by creosoting the sleepers.

In the fourth story, where some of the washing machinery will be located, the concrete floor has been thoroughly waterproofed by means of a waterproof layer placed upon the top of the concrete slab. Upon the waterproofing a cinder concrete filling is laid, on top of which a wearing surface of cement is placed, composed of 1 part cement, 1 part sand and 1 part finely crushed trap rock. The top surface is graded and the gutters formed for carrying off the water. Where the washing machines occur on the first floor the ordinary form of cement flooring is laid, consisting of a bed of well-tamped cinders, upon which is placed 3 in. of concrete and a 1-in. top coat of cement, graded and provided with gutters.

The roof construction is similar to that of the floors, the concrete slab being in that case 3½ in. thick, and is waterproofed with a top covering of felt and slag.

A reinforced concrete stairway with a fireproof enclosure affords means of communication between the several floors, as does also an elevator similarly enclosed. In addition, there will be a dumb-waiter and several chutes for expediting the transmission of articles between stories. Modern toilet accommodations are provided on each floor.

Boiler and engine rooms, completely isolated from the remainder of the building, are located in the rear of the first story of the building.

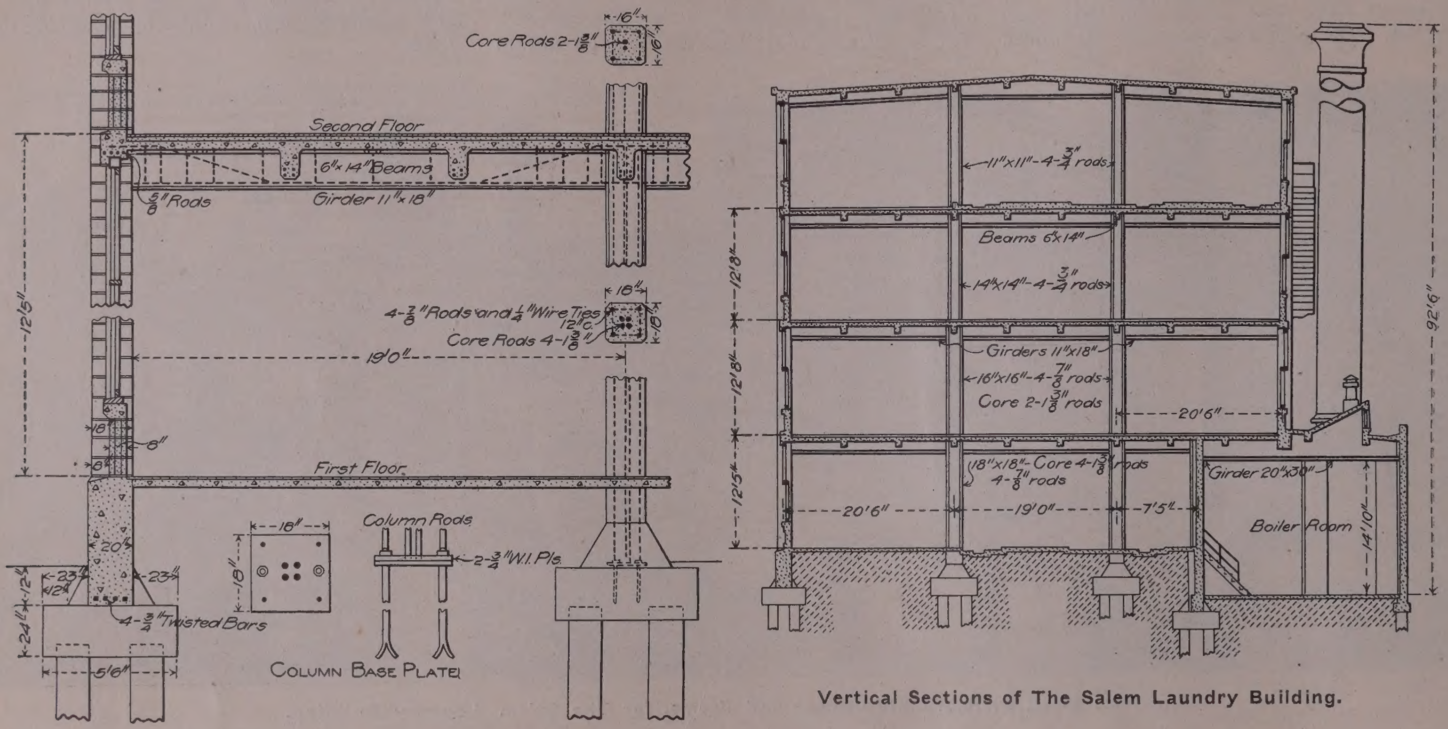
Two 150-h.-p. return tubular boilers have been installed, which will supply steam for a Corliss engine, pumps, laundry machinery and heating system. Draft for the boilers will be provided by a chimney of 4 ft. inside diameter and 93 ft. high, constructed of concrete blocks filled solid and thoroughly reinforced with twisted steel bars similar to the walls of the building and surmounted by an ornamental top.

The building has been fully equipped for the economical handling both of what is known as "wet" wash and of "finished" work. The "wet" wash will be handled entirely upon the first floor of the building, where washers and extractors will be installed especially for this purpose. After being washed and the surplus water extracted the articles of the "wet" wash are ready to be returned to their owners.

The "finished" work upon its arrival will be sent to the fourth floor, where it will be sorted and put through the washers and extractors. Small work will be dried and starched on the same floor, and then sent by chutes to the third floor to be ironed. Large articles will be transmitted direct from the fourth floor through a chute to the second floor, where large mangles will be located.

On the second floor the articles for each customer will be collected and bundled, those intended for wagon delivery being arranged according to routes and sent through a special chute to the delivery room in the rear of the first story. Bundles to be called for will be sent by dumb-waiter to the delivery counter in the first story front. The business and private offices, as well as the main entrance to the building, will be located on the Lafayette St. front of the building.

The entire work of designing and supervising the erection of the building was in charge of Ballinger & Perrot, architects and engineers, Philadelphia.



Vertical Sections of The Salem Laundry Building.

A New Coal Field is being opened up in California near the coast, between San Francisco and Los Angeles, which is expected to have an important effect on the fuel supply conditions in that State. Unlike most beds in the State, which are lignitic in character, this one is a seam of semi-bituminous coal, 18 ft. thick. About 1½ miles of gangways have been opened up, and it is expected that the mines will soon be producing several hundred tons of coal per day.

The Construction of the Queens Approach to the Blackwell's Island Bridge.

The east approach to the Blackwell's Island Bridge in Ravenswood, Borough of Queens, consists chiefly of a steel viaduct structure, 86 ft. wide over all and 1,433½ ft. long which carries a roadway, two sidewalks and six railroad tracks from grade at the outer end to a height of about 100 ft. above the surface of the ground at the anchor pier. It consists of steel towers and single intermediate transverse bents supporting two lines of riveted trusses 60 ft. apart and 25½ ft. deep on centers with spans. The girders have spans of 56 to 166 ft. and carry two decks, as described in The Engineering Record of Dec. 7, 1907. The plant has been installed and operations commenced adjacent to the anchor pier for the erection of the first section of the structure. These foundations are nearly completed and much of the steel has been delivered. Preliminary work has also been commenced on the second section which includes the remainder of the steel superstructure to Crescent St. and the solid fill.

The sub-structure for the first section of the approach consists of twenty concrete piers in two lines 60 ft. apart on centers. All piers are carried down in open pits to the solid rock at depths of 30 to 50 ft. below the original surface of the ground. The excavation was chiefly through quicksand with some boulders and in places through an 18-in. stratum of decomposed water bearing rock. The pits are lined with tongue and groove sheeting from 2 to 4 in. thick which was at first driven by a 500-lb. pneumatic hammer of the heaviest pattern manufactured by the Kiernan Drill Co. It was operated at a pressure of 75 lb. and struck about 100 blows per minute. The inside excavation was maintained within about 3 ft. of the bottom of the sheet piles but the exterior pressure and friction was so great that the hammer would not drive them more than about 20 ft. After reaching this stage a 500-lb. drop hammer was installed and continued the work satisfactorily. Generally the water was drained from the pits by use of ordinary ejectors, but in cases where the flow was larger than usual it was cared for by a Cameron steam pump with an 8-in. suction and 6-in. discharge pipe which was quickly moved from pit to pit as required.

The concrete piers are built with either five or six courses having vertical sides and 6-in. offsets except between the first and second courses where the offset is 9 in. The dimensions of the first course vary from 12x12 to 12x16 ft., according to depths. The height of the first course varies with the depths of the pit to a maximum of about 25 ft. and covers the entire area of the pit requiring no mould other than is formed by the sheeting. The upper courses have a uniform height of 4½ ft. and are made in ordinary forms bolted together with angle irons and tie rods. The lower courses are proportioned 1:3:6 and the two upper courses are 1:2:4.

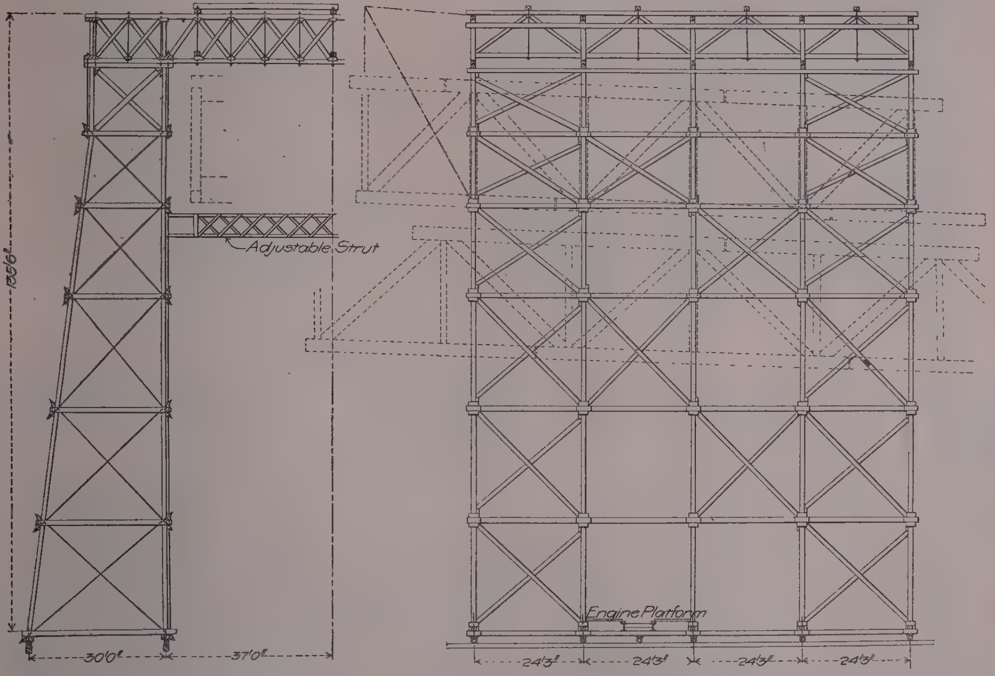
A pair of 12-in. horizontal reaction channels receives two 2½-in. anchor bolts about 10 ft. long cast in the concrete of the upper course. The piers rise nearly 10 ft. above the original surface of the ground to provide for the proposed grade after the fill is completed. Each pier is capped with a 7½x10-ft. granite pedestal 3 ft. deep, made in two pieces and drilled from both sides with a 3-in. drill for the anchor bolts.

Stones, sand, cement and other materials are delivered by boat to the dock near pier IV, where they are unloaded by a boom derrick. From the dock they are transferred over a 3-ft. track on a falsework trestle by which also cement, steel, and other materials are delivered. Stone and sand are taken to the concrete plant and stored in two flat bottom bins of about 500 yd. capacity each, which are elevated from 3 to 12 ft. above the surface of the ground to provide sufficient clearness for the concrete mixer below them and have vertical sides 5 ft. high. The stone and sand are handled in 2-yd. wooden buckets with angle iron corners and steel trimmings which are transported by flat cars and unloaded into the bins by a boom derrick operated by a Lidgerwood hoisting engine.

Stone and sand are wheeled from the storage bins to the charging hopper of the concrete mixer which is filled to the proper gauge marks and receives the corresponding number of bags of Lehigh or Alpha Portland cement. The 1-yd. Ransome concrete mixer delivers into bottom dump steel buckets on flat cars or by Wonham & Magor steel dump cars, both of them running on the 3-ft. surface track to all foundation piers. The concrete mixer has a capacity of 200 cu. yd. a day which, of course, is restricted by the rapidity with which the concrete can be removed from it, but which, under favorable conditions, has reached this limit. About 3,000 cu. yd. of concrete has already been deposited in the foundations and the corresponding excavation amounts to about 4,000 cu. yd. of earth and a small quantity of rock besides about 10,000 yd. of fill and 1,000 yd. of rock excavation for the grading of sides of the foundations.

All of the derrick engines are operated by compressed air at about 100 lb. per square inch which is delivered from a central power station where there are installed three 60-h.p. horizontal boilers and an Ingersoll-Rand air compressor of a capacity 4 cu. ft. per revolution. The air is carried along the surface of the ground in a pipe 2½ in. in diameter at the receiver with outlets 100 ft. apart. Adjacent to the power house there is a small machine and repair shop and a blacksmith shop, carpenter shop and store house.

Preparations have been made for the erection of the 10,000 tons of steel in the superstructure for this part of the contract by means of a tower traveler moving on the surface of the ground in front of and retreating from the finished bridge. The traveler is 135 ft. high, 134 ft. wide and 75 ft. long on centers with vertical and horizontal clearances of 125 ft. and 73 ft. respectively. It has five bents each made with two vertical and two inclined batter posts connected at the top by a Howe truss 10 ft. deep with top and bottom chords made with pairs of 6x10-in. timbers. The vertical and inclined posts in the tower are all made with single 10x12-in. timbers divided into six panels by single 10x12 or double 4x12-in. horizontal pieces. Each panel is X-braced by a pair of screw and diagonal rods and the feet of the vertical and inclined posts are seated on a single 12x12-in. longitudinal stringer. There are twenty-four 12-in. flanged wheels, under the sills, one at each post. The wheels travel tandem on four 80-lb. rails laid on 12x12-in. sills.



Erection Traveler for Queens Approach, Blackwell's Island Bridge.

The traveler bents are connected longitudinally by 24 horizontal lines of 8-12-in. timber in the planes of the transverse struts and with wooden X-braces in every panel of the end bents and in four intermediate panels of the intermediate bents in each line of posts. They are also connected by three trusses 10 ft. deep on the center line of the traveler and about 30 ft. each side of it. The top and bottom chords of these trusses are respectively pairs of 6x12 and 6x10-in. timbers and are seated on the top and bottom chords of the transverse trusses. The trusses are divided by vertical tie rods into 12-ft. panels and serve as jigger beams from which tackles for hoisting the steel structure are suspended at panel points. On each side af the traveler the lower sills carry 24x30-ft. horizontal platforms on which are installed Mundy hoisting engines.

A large amount of grading was done on the axis of the bridge to provide a level surface about 15 ft. below the bases of the steel viaduct columns on which the traveler tracks were laid on timber cribbing and the erection of the traveler was commenced in August last. Each longitudinal half was assembled as a separate tower by means of derrick booms carried upon the structure as it was erected. These three lower panels of timber work of one tower had been erected and the transverse X-brace rods were assembled in the lower panel when they were wrecked by a violent wind and electric storm which shattered the timbers and made it necessary to renew them. The traveler was completed about the 15th of October and it is expected that the erection of the steel work will be commenced when steel for the first tower is received.

The approach is designed and its construction supervised by the Department of Bridges, New York, Mr. J. W. Stevenson, commissioner, Mr. C. M. Ingersoll, Jr., chief engineer, Mr. O. F. Nichols and Mr. Austin Lord Bowman, consulting engineers. The Buckley Realty Construction Co., Mr. R. W. Buckley, president, is the contractor for this section, Mr. Chas. O. Brown, consulting engineer, and the structural steel is fabricated by the American Bridge Co. For section II of the approach, the Maryland Steel Co. is the contractor for the structural steel and the Snare & Triest Co. is the subcontractor for the substructure and for the erection of the steel, and has commenced work.

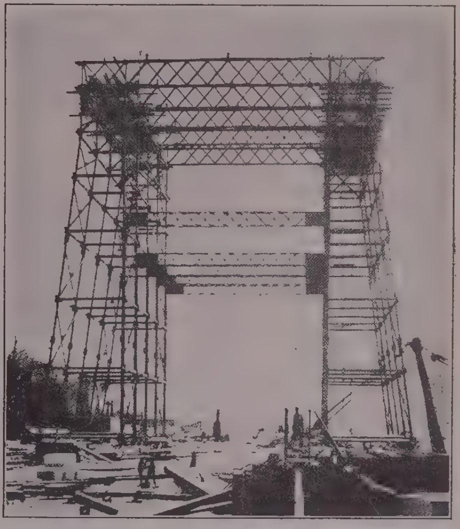
The Largest Gas-Holder in the world has recently been completed at the Astoria works of the Consolidated Gas Co. of New York. It is 253 ft. high with five lifts of about 46 ft. each, the largest one 297 ft. in diameter. The unit of which the holder is a part has a capacity of 6,000,000 cu. ft. of gas per 24 hours, and the capacity of the holder is 15,000,000 cu. ft. The holder was built and erected by Messrs. Bartlett, Hayward & Co., under the direction of Mr. W. H. Bradley, chief engineer of the gas company. It is practically a standard type holder, but its unusual size necessitated special details.

Foundation Work for Six Lift Bridges.

By C. M. Ripley, New York City.

The running of the new East Chicago canal from the inland to its junction with Lake Michigan at Indiana Harbor, Ind., where it connects with the ore unloading slip of the Inland Steel Co.'s plant, makes necessary lift bridges in the tracks of all those railroads which skirt the southern lake shore on their way east. The Pennsylvania R. R., with two tracks, is farthest from the shore of the lake; the Lake Shore & Michigan Southern, with six tracks, is next; the Baltimore & Ohio R. R. is next, with two tracks, and the Chicago, Lake Shore & Eastern Ry., with two tracks, is closest to Lake Michigan.

The average amount of excavation for the piers of these lift bridges is about 5,000 cu. yd. for each two-track structure. The work on the Lake Shore & Michigan Southern is three times as large as that on any of the other roads here and will be considered more in detail than the other three jobs. Since three double-track bridges are to be built side by side on this job, the excavation work is obviously less in amount per double track than is the case with the other three separate jobs, which have only one double-track bridge each.



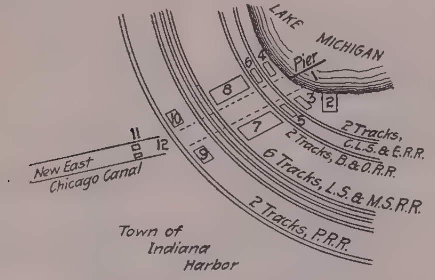
Erection Traveler, Queens Approach.

At the beginning of the work the Lake Shore people drove and jetted Wakefield sheet piling of 2 x 12-in. yellow pine 32 ft. long. These were so overlapped as to make 3 ft. of piling measured horizontally for every foot of periphery around the cofferdam, which is 42 x 105 ft. One 2,000-lb. drop hammer, with a gang of twelve men at an average of $2.45 per day, drove 15 peripheral ft. of the sheet piling on an average each day. Since jetting was employed, the piling generally sank under the weight of the hammer, and very little driving was needed in this portion of the work. From about the middle of September until the first week in November the excavation work had been carried down 26 ft. and foundation pile driving started. Ten men at $1.60 per day, one hoisting engineer at $3 per day and two men at the gondola car, dumping the 1-yd. cylindrical buckets, constituted the gang for this work. As the work progressed onward through 8 ft. of dry sand, 9 x 18-in. waling pieces, with the flat sides against the sheet piles, were run at a depth of 6 ft. below the top of the sheet piling all the way round the cofferdam. Cross-bracing of 9 x 18-in. timbers, with their longest dimension vertical, were then strung across the cofferdam at intervals of every 15 ft., measuring along the longest dimension and every 14 ft. along its shortest dimension. Two different lengths of these cross pieces were used, approximately 14 and 28 ft., and employed alternately or staggered.

Vertical posts were set at the junction of the longitudinal and transverse bracing, as shown, and a 4 x ½-in. forged angle, each leg 5 in. long and containing two holes, was used in connection with 8-in. lag screws to fasten the horizontal bracing to the vertical uprights.

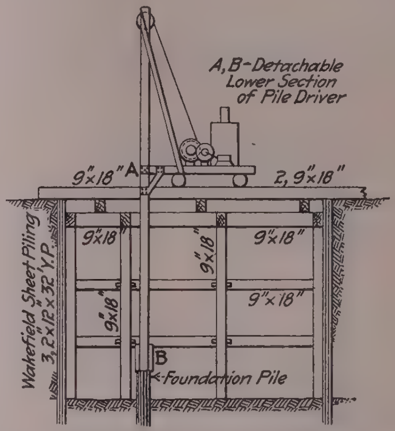
As the excavation was carried down, new waling pieces were added at intervals of approximately 5 ft. each until the full depth of 28 ft. was reached. These lower waling pieces, however, were composed of two 9 x 18-in. timbers, lagged together and placed with their narrowest dimension against the sheet piling, in order to gain additional strength. Beneath those points where the waling pieces and the cross-bracing intersected, vertical 8 x 16-in. timbers were lagged on with the flat side against the sheet piling, as shown.

At a depth of about 8 ft. below the surface the excavation became wet, and two type B Emerson Junior pumps, rated at 180 gal. per minute, each with 4-in. suction and 3-in. discharge pipes, were hung from the upper timbers. These sufficed for unwatering the excavation down to its lowest level, 25 ft. below the water line, and during the time the foundation piles were being driven. Two other Emerson pumps were used in the cofferdam for the smaller pier. These only weighed 250 lb. each, the superintendent said. A total of 1,200 piles was driven in the main and minor excavations, and 24 men, averaging $2.45 per day with one 2,800-lb. and one 2,000-lb. drop hammers in 65-ft. leads, drove an average of 30 piles per day, each pile approximately 45 ft. long.

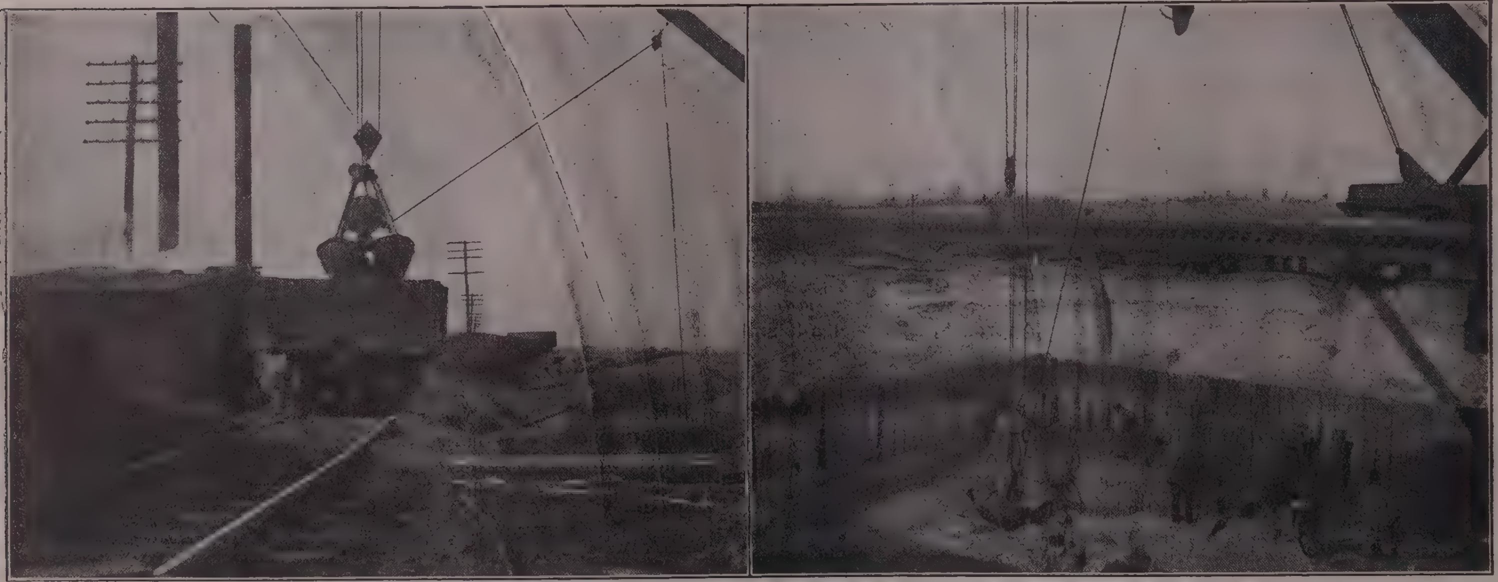


Location of Lift Bridges.

Inside of L. S. & M. S. Cofferdam.


A, B-Detachable Lower Section of Pile Driver
9"x18"
A
2, 9"x18"
9"x18"
9"x18"
9"x18"
9"x18"
9"x18"
B
Foundation Pile
Wakefield Sheet Piling 3, 2"x12"x32' Y.P.

Cofferdam, L. S. & M. S. Ry.



Views Showing Method of Excavating at Cofferdam of Pennsylvania R. R. Bridge.

The method of mounting the pile drivers is shown in the sketch. Two 9 x 18-in. timbers were lagged together with joints staggered and in lengths of approximately 30 ft., so as to make an 18 x 18-in. girder 60 ft. long. Two of these girders spaced about 10 ft. apart rested upon the upper tier of cross-bracing. Across these two girders were laid two 10-in. extra heavy wrought iron pipes, which served as rollers for the double-drum Lidgerwood hoisting engine which operated the drop.

Since the piles were not driven until the excavation had reached its lowest level, there were four different tiers of cross-bracing, which interfered with the lateral movement of the pile driver leads; instead, therefore, of lifting the entire 65-ft. leads out of the excavation whenever the progress of the piling driving made it necessary to cross a horizontal timber, the lower 30 ft. of the pile-driver leads was made detachable. By merely taking out eight bolts the hoisting engine lifted this lower section above the upper tier of cross-bracing and the engine was pushed over into the next shaftway, where the lower section was again dropped into place and the pile driving resumed, a change requiring little over five minutes.

A 1-yd. Hayward orange peel bucket was used in the excavation work for the Pennsylvania R. R. bridge. Mr. Fred Tapp says that the operation of this bucket makes it possible to excavate and load into gondola cars over 150 yds., part wet and part dry, each day.

For the unwatering of the Pennsylvania excavation the contractor employed one No. 3 Emerson standard pump of a capacity of 725 gal. per minute, with 5-in. suction, 4-in. discharge and 1¼-in. steam pipes. A similar size was used in the Baltimore & Ohio excavation, and another of the same size used in the Chicago, Lake Shore & Eastern excavation.

On October 10, when the writer visited the scene of this work, the concreting of the Chicago, Lake Shore & Eastern pier was well under way. Portland cement concrete, mixed 1:3:5, was being lowered between the cross-bracing in Excelsior bottom-dump buckets of 1-yd. capacity. These buckets were previously used in hoisting the excavated material and worked very satisfactorily in the confined spaces where it was necessary to deposit the concrete. The Tapp Construction Co., on the various jobs which they have under way on this bridge work, are using six No. 3 Smith mixers and depositing approximately 400 cu. yd. of concrete per day. The company is represented by Mr. Fred Tapp, engineer in charge. The Lake Shore & Michigan Southern R. R. work is in charge of Mr. W. R. Gravitt, assisted by Mr. W. H. Saunders, master carpenter. The Lake Shore cofferdam work and cross-bracing was unusually substantial in character, owing to the fact that the railroad company could avail themselves of the chords taken out of old wooden bridges and trestles. The 9 x 18-in. timbers came from this source and altogether the Lake Shore people shipped to the job 120,000 ft. B. M., of lumber for the substructure.

A 24,000-H.-P. STEAM TURBINE will be constructed at the Mannheim works of Messrs. Brown, Boveri & Co., for the steel works and blast furnace plant of Messrs. Krupp, at Rheinhausen. This is probably the most powerful turbine for stationary service yet ordered.

Arrangement of Railroad Shops.

A paper read before the Canadian Railway Club on Jan. 7 by George A. Damon, Managing Engineer, The Arnold Company, Chicago.

Railroad repair shops cost money, both to build and to operate. Just at this time it may be of interest to approach the subject of their design, arrangement, and equipment from a financial standpoint. There is hardly a better field for demonstrating that "engineering is the science of making a dollar go the farthest" than the art of designing and building railroad repair shops, and, as nearly all work of this character must start with an "A. F. E." (authority for expenditure), or perhaps an "appropriation," it will be instructive to inquire just how great an investment in repair shops will ordinarily be justified.

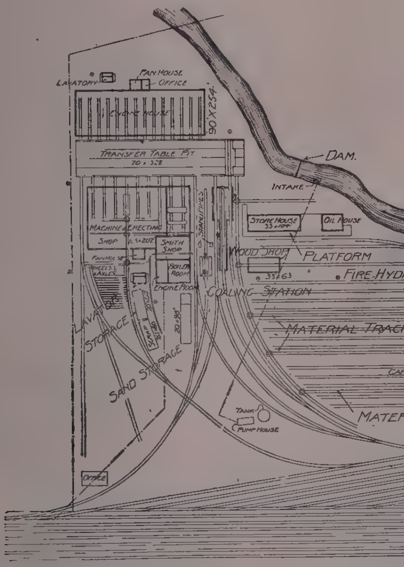


Fig. 2. Ivorydale Shops, Cincinnati, Hamilton & Dayton Ry.

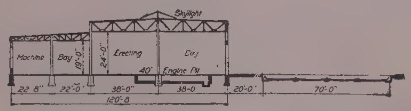


Fig. 3. Cross-Section, Main Shop.

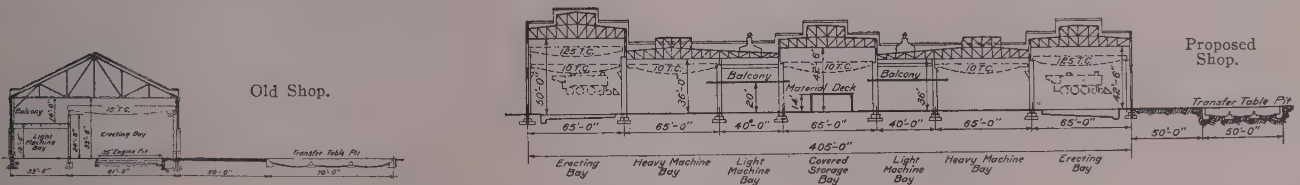


Fig. 1. Cross-Sections of Old and Proposed Shops at Oelwein, Iowa.

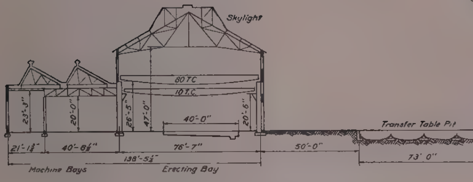


Fig. 5. Cross-Section, Main Shop.

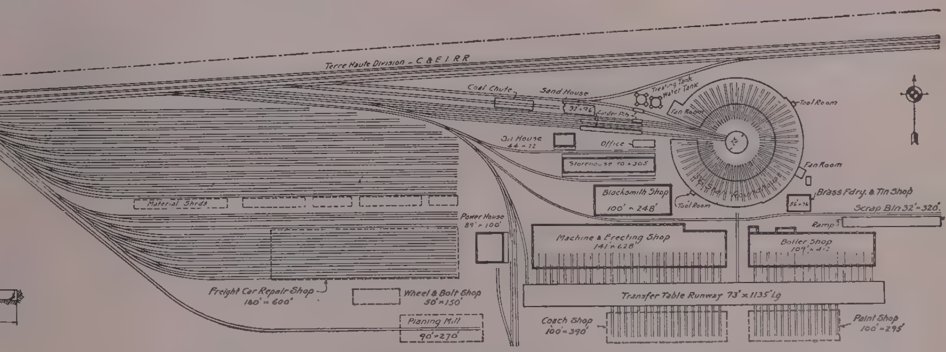


Fig. 4. Oaklawn Shops, Chicago & Eastern Illinois R. R.

The original cost of an average modern locomotive may vary from $14,000 to $17,000. The actual expense for labor and material to maintain this locomotive in first-class condition will range from $1,500 to $3,000 per year, each road, of course, having its own individual conditions that influence this cost, and which make it impossible to establish an absolutely definite figure. For our present purposes, however, it may be said that a locomotive costing $15,000 will involve a maintenance cost of about $2,250 per annum, and this expenditure should go far toward overcoming the natural depreciation of and wear on the equipment, and thus keep the locomotive in first-class running order.

The original investment in a complete new locomotive repair shop, fully equipped to make these repairs efficiently, will depend on the location, the size, the design, the selection of the equipment and the cost of labor and material entering into the buildings. These factors are so variable that it is impossible to determine an average that can be regarded as an exact standard. Even an approximate estimate for any given case can only be obtained after a detailed study has been made of the conditions surrounding the particular problem in hand. The following figures must, therefore, be used with judgment, or they may be misleading. These figures have been taken from the records of the actual cost of a number of repair shops with the design and construction of which the writer has been connected. The fact that there is such a wide variation emphasizes the danger of deriving a general law from any particular experience, or even of drawing a conclusion for a particular case from a general experience.

The figures, however, should be of assistance in determining the limits outside of which it will ordinarily be unwise to go. To spend less money than indicated in the "low" estimate might be the result of a fortunate set of circumstances contributing to economy, but every precaution should be taken to insure that the saving accomplished is not at the expense of a false economy. To spend more money than indicated by the "high" estimate may be desirable, or even necessary in certain cases, but ordinarily the higher figures are sufficient to cover all repair shop needs, unless it is the intention of those in charge of the work to erect a monument.

The writer has purposely approached this subject of cost with considerable caution, and it is only because the literature of shop building is so meagre of actual cost data that the risk has been taken of having the figures misunderstood, and therefore the information misapplied.

Our records show that locomotive repair shops which are laid out on a basis of the number of pits required equal to 6 per cent. of the number of locomotives served can be built and equipped complete for an expenditure ranging between $50,000 and $65,000 per pit. If one pit will serve sixteen and two-thirds engines per year, the cost of repair facilities will fall some place between the limits of from $3,000 to $4,000 per locomotive. An investment amounting to the lower limit is absolutely necessary if the engines are to be kept on the road. Just how much more than the lower limit should be spent in order to secure the minimum cost of locomotive maintenance, including all the items of not only actual repair expenses, labor and material, but also interest, depreciation, insurance and taxes upon the plant provided, is a question that should have the most careful consideration.

The analysis in Table 1 of the total cost will serve to indicate the relative importance of the decisions that must be reached in order to give each dollar expended a maximum earning capacity. The sum total of the "low" and of the "high" figures shown will result in grand totals which will show a wider range than the 33⅓ per cent. variation indicated by the unit figures of $3,000 to $4,000 per locomotive, but as it is improbable that any shop would be built using either the lowest or the highest estimate for every one of its parts it will be found that only in exceptional cases will the actual total cost fall outside of the limits first given.

Table 1.—Cost Limits for Locomotive Repair Shops on the Basis of Twenty-five Erecting Pits.

	Limits of Cost Per Pit		Approx. Proportion of
	Low.	High.	Tot. Cost.
Shop Yards—			
Tracks, crane runways, transfer or turn tables	$ 1,400	$3,000	4%
Water and sewer systems	1,000	1,800	2%
Piping and wiring tunnels and tunnel piping	500	1,000	1%
Buildings—			
Machine and erecting shop	8,000	12,000	17%
Boiler and tank shop	3,000	5,000	7%
Forge shop	1,500	2,400	4%
Storehouse and offices	1,000	2,500	3%
Locomotive carpenter shop	500	1,000	1%
Power house	1,200	2,400	3%
Oil house and equipment	400	600	1%
Miscellaneous Buildings—			
Scrap bins, material sheds, fences	500	1,000	1%

General Equipment for All Departments—			
Power house equipment........	5,000	8,000	11%
Traveling cranes	1,500	3,000	4%
Tool equipment	10,000	15,000	22%
Heating system	1,200	2,500	3%
Power and lighting systems, including yard wiring and lighting	1,500	4,500	5%
Plumbing and lockers..........	300	1,000	1%
Air, water, steam and oil piping in buildings	600	1,200	2%
Incidentals, organization and engineering	2,000	7,000	8%

Note.—These figures do not include items for real estate and preparation of the shop site, which cost necessarily varies between wide limits.

The foundry building and equipment are not included in these figures.

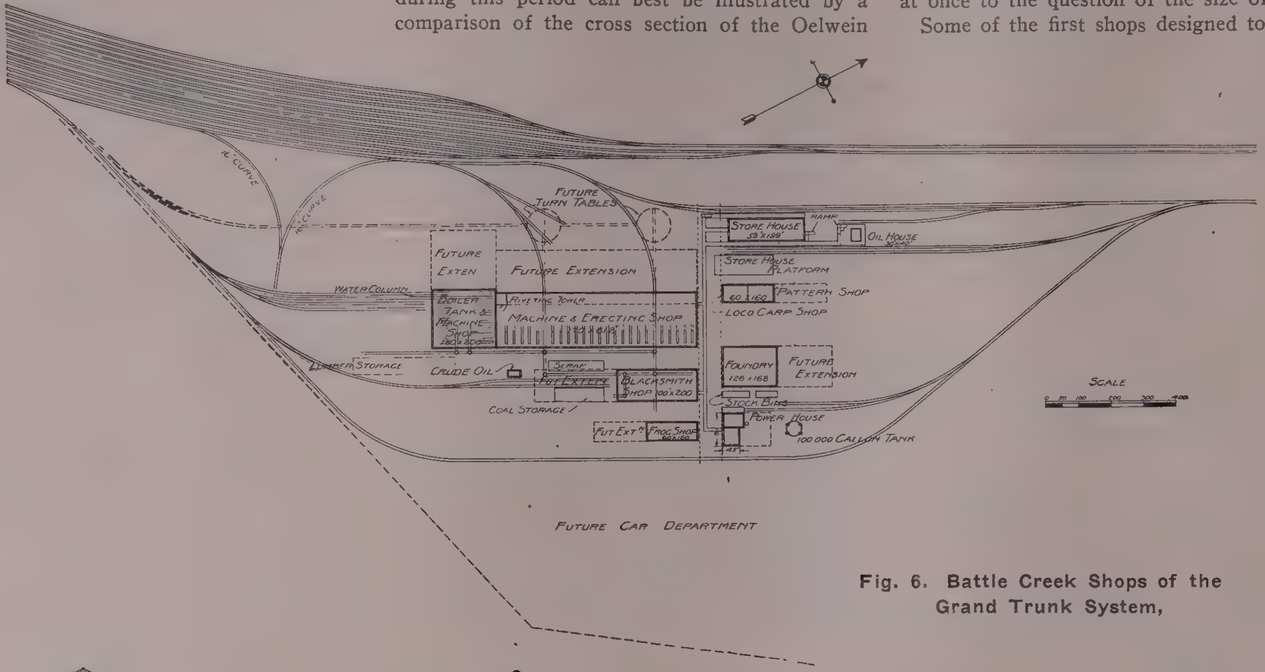


Fig. 6. Battle Creek Shops of the Grand Trunk System,

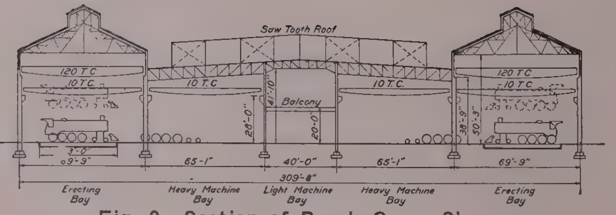


Fig. 9. Section of Beech Grove Shops.

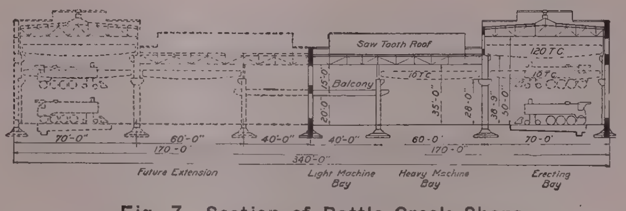


Fig. 7. Section of Battle Creek Shops.

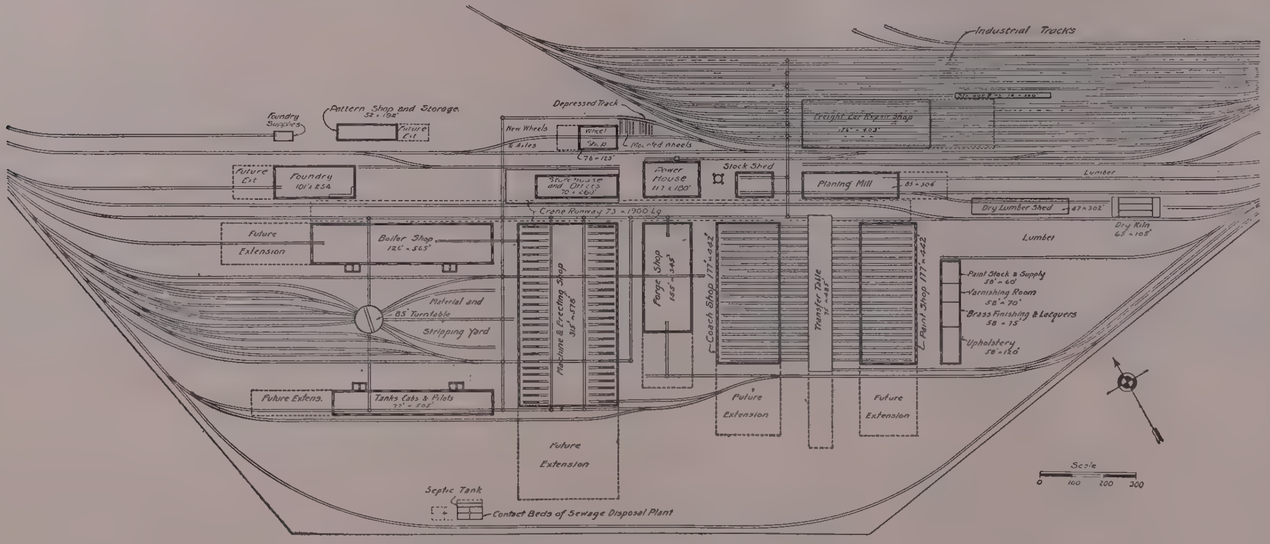


Fig. 8. The Shops of the Big Four System at Beech Grove, Ind.

The history of "modern" locomotive repair shops may be considered as beginning with the use of what has been called "the electric drive." The use of the electric motor makes possible (a) the arrangement of departments independent of the line shaft requirements; (b) the use of electric cranes; and (c) the construction of all power producing equipment in one central power plant from which may be distributed heat, water, compressed air, light, and power.

One of the first shops to make use of the electric motor for both individual machines and groups of tools, as well as the electric crane and the central power plant, was the Oelwein, Iowa, shops of the Chicago Great Western Ry., which were put in commission in 1900. Since that date there have been over seventy shops either built entirely new or modernized from previously existing plants. It is safe to say that more than $80,000,000 has been expended upon railroad repair shops and their equipment within the last ten years.

The advance that has been made in the art during this period can best be illustrated by a comparison of the cross section of the Oelwein machine and erecting shop and the cross section of a shop for a similar purpose which is now under consideration, as shown by Fig. 1. The Oelwein erecting shop was equipped with one 80-ton crane and one 15-ton crane, both upon the same runway over the erecting pits. The second and more recent example has one 120-ton crane operating over the erecting pits on a runway above the two 10-ton messenger cranes, while the machine shop is supplied with two 10-ton cranes over the heavy tools, and an additional crane is provided over the covered yard.

It is needless to say that the more elaborate equipment of the latest development in repair shops costs more than the more modest shops which first adopted the electric system, but at the same time locomotive equipment has been gradually increasing in size and cost in such a way as to make these more extensive repair shop facilities an absolute necessity. Care must be exercised, however, to insure that the repair facilities provided are not greater than the needs of the equipment to be served, which brings us at once to the question of the size of the shops.

Some of the first shops designed to use a central electric power plant were handicapped by the use of the 220-volt direct-current electric system, which made it desirable to limit the radius of distribution to about 1,000 ft. from the generating plant. The development of the induction motor and the alternating system soon removed this limitation, but as it was still necessary to use the direct-current motor to obtain satisfactory electric speed control on many of the independent motor-driven tools, a mixed electric system was adopted by many shops. It is still the practice in a number of recent installations to provide both direct and alternating current throughout the shop—using direct current for the cranes, variable speed motors, and perhaps the mercury vapor lamps, and alternating current for the constant speed motors, incandescent lights, and the yard lighting systems. The recent improvements in mechanical speed-changing devices; the development of the alternating current crane, and the reduction in cost of the induction motor are creating a decided tendency toward the elimination of the direct-current system. By these improvements it is possible to distribute power from a central plant over a larger area and also remove the old limitations of the amount of ground covered by the shop plant.

The size of a locomotive repair shop will depend primarily upon the number of locomotives to be repaired each year, and the number of days each locomotive under repair must occupy an erecting shop pit. To the pits required for "heavy" repairs must be added a number of pits for "light" repairs, for emergency work, and for future growth. The ratio of the number of pits to the number of locomotives will vary with the assumptions as follows

Let A = Number of locomotives served by shop.
B = Percentage of locomotives to undergo "heavy" repairs each year.
C = Average number of days each locomotive occupies an erecting shop pit.
D = Number of working days each year.
P = Number of pits required for "heavy" repairs.
P' = Number of pits required for "light" repairs.
P'' = Total number of pits required.
Then $P = ABC/D$ and $P'' = P' + P$.

The effect of the different assumptions as to the percentage of the total number of locomotives to be repaired each year and the length of time on a pit are shown by Table 2, which was prepared for a shop serving 400 locomotives at present, with a probable increase to 500 within the next five years.

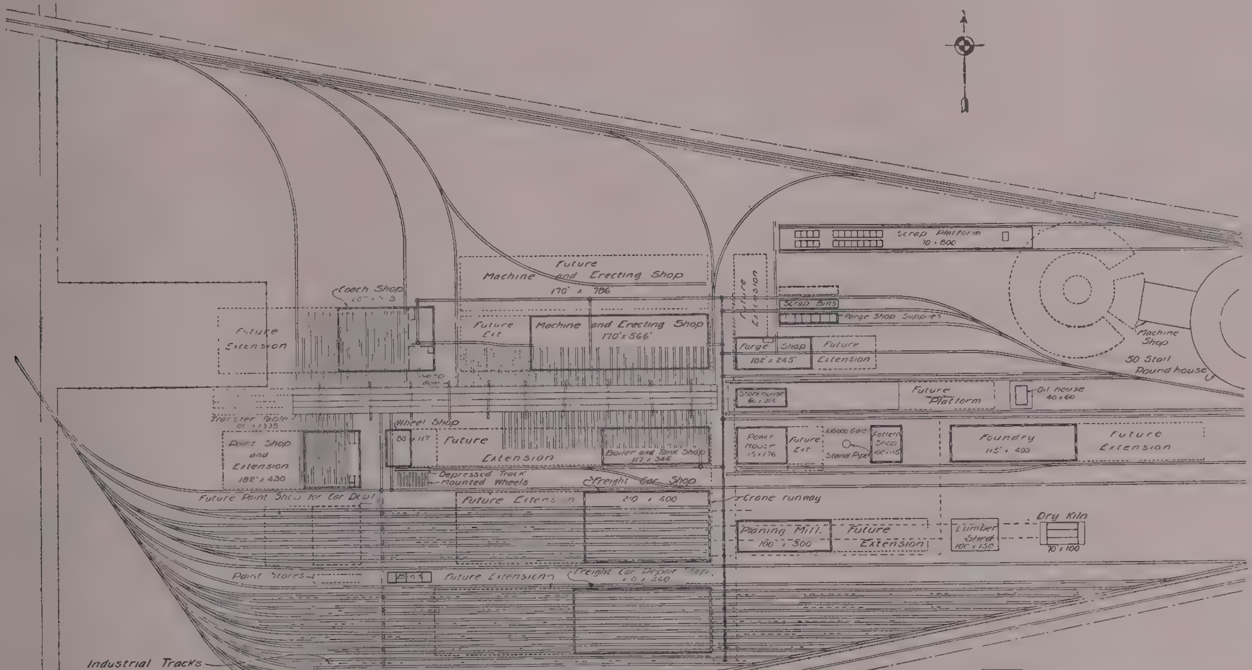


Fig. 10. Springfield Shops, Frisco System.

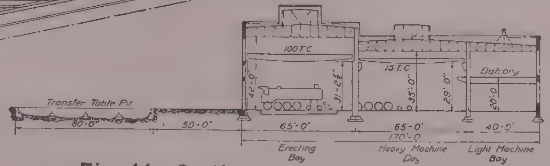


Fig. 11. Section of Springfield Shops.

TABLE 2.—RESULTS OF DIFFERENT ASSUMPTIONS AS TO REPAIRS.

No. of Locomotives.	Percentage Repaired.	Days in Shop.	Working Days in Year.	Pits, Heavy Repairs.	Pits, Light Repairs.	Total Pits.		
A	*B*	*C*	*D*	*P*	*P'*	*P''*	*P'/P*	*P''/A*
500	80%	20	288	28	7	35	25%	7%
500	70%	17	288	21	9	30	43	6%
500	60%	14	288	15	10	25	66	5%

From table 2 it will be seen that the number of pits may vary from 5 to 7 per cent. of the total number of locomotives, which variation corresponds with actual practice.

Individual conditions will govern the assumptions for each road, and there are, fortunately, a number of other methods of checking these calculations.

The size of the machine shop space per pit depends largely upon the methods adopted for operating the shop. The work on the pit can be crowded, and the erecting output under normal conditions can be doubled during rush periods, but the output of the machine tools cannot be increased in the same ratio. The tendency at present is to favor the amount of floor space allowed for machine tools. On the other hand, the use of high-speed tools is rapidly increasing the output of each machine, and this development is contributing to the output efficiency of each foot of machine tool space. The space per pit for machine tools varies from 1,500 to 2,500 sq. ft. This result is often largely influenced by the demands made upon this space for manufacturing new work, or for supplying repair parts to other shops.

An average rule for the size of the boiler shop is to allow one-third as much space for this department as is allotted to the machine and erecting shop, but this rule is affected by the character of boiler repairs to be made. The kind of coal, the conditions of the water supply, and whether or not new boilers are to be constructed must be known before a final decision can be reached.

The blacksmith shop is ordinarily one-third the size of the machine and erecting shop, but local conditions must again be carefully considered before reaching conclusions. The safest way for all shops is to canvass the requirements for output and the capacity and floor space required of each machine, and then design the shop to fit the machines, rather than crowd or spread out the machines into a space the size of which has been too hurriedly determined.

The preliminary considerations which must have attention before the problems of relative arrangement of the buildings can be approached involve so much of the "personal equation" that only tendencies of recent practice can be noted, and no hard and fast rules can be established.

It is not the province of this paper to discuss the advantages and disadvantages of the various points which must be thoroughly canvassed in order to reach consistent preliminary conclusions, as these subjects have been already covered by special books and technical papers, which are available to those who are interested enough in these subjects to study them in detail. To indicate briefly the problems which must be considered and decided upon by the shop designer early in his work on any particular layout will, however, be of value.

For instance, the question of "transverse shop versus longitudinal shop" for the erecting bay must be settled before much progress can be made. The tendency appears to be in favor of the transverse shop, but the writer must admit that his own personal equation enters into this conclusion.

Whether or not the boiler shop shall be under the same roof with the machine and erecting shop is a question that is usually settled by the experience and preferences of those who are to operate the shop.

The use of a transfer table or a turntable as a means of getting locomotives into the shop is a subject upon which volumes have been and can be written, but this question is usually decided in favor of the desires of the operating official who is to have charge of the shop after it is completed.

The use of yard cranes, telphers, or locomotive cranes for handling materials outside of the buildings is being given more careful attention than formerly, with the result that these auxiliary transportation systems are having a marked influence upon the arrangement of shops. There is a tendency to cover a portion of the yard with a crane, and locate the lye vats and tire furnaces in this covered yard.

The location of the store house and the oil house will depend upon their individual use, whether it is the intention for them to serve the entire system or not.

Fireproof concrete construction is having an effect upon bringing the store house closer to the various departments to be supplied, the tendency apparently being to locate the store house contiguous to the machine and erecting shop, as was originally done at Oelwein.

Whether to locate the car repair department contiguous to the locomotive repair department is a question of policy for the management to decide, and the answer depends largely upon local conditions of operation and organization. The location of the car repair tracks, the desirability of having the common power house near the planing mill to burn refuse, and the location of the forge shop convenient to both departments has a marked influence on the general arrangement of the shops.

The location of the shop itself, as influenced by traffic conditions of the system, and the selection of the shop site after the general location has been decided, are questions in the solution of which serious mistakes have been made. Recent decisions seem to indicate a tendency to locate shops as near as possible to favorable labor markets, instead of in smaller towns, or at some inconvenient distance from the larger cities.

Certain fundamental principles should be recognized before attempting a railroad shop arrangement, and as far as possible the arrangement should be worked over until it satisfies these requirements, always recognizing exceptions due to individual conditions.

(1) Liberal space (say 100 per cent) should be allowed for the extension of each department.

(2) The store house (with administrative offices in one of the upper floors) should be central, convenient to all departments and easy of access on two tracks from the main line service track.

(3) The forge shop should be convenient to both the locomotive and car repair departments.

(4) The power house should be central and near the planing mill and repair tracks, in order to burn refuse.

(5) Yard cranes should be arranged to serve between the store house platforms and all departments.

(6) The round house should be very near the shop, or located far enough away to justify a separate machine shop for light repairs.

(7) Tracks, cranes, telphers and storage spaces should be arranged to insure the movement of materials with the greatest economy of time and labor.

(8) Some consideration should be given to the appearance of the shops and accessory storage facilities, lumber yards, etc., from the main line.

(9) The advantages of a short tunnel of ample cross section for the use of the various steam, air and water piping systems should not be forgotten.

(10) The possibilities of the adoption of longer and heavier engines similar to the consolidation or articulated types should be considered, and some provision made for present or future repair facilities for these larger engines.

(11) The cost of the shops should be consistent with not only the actual necessities, but in proportion to the refinements which the road can afford. All expenditures over and above those required for actual needs should be capitalized and made to show a satisfactory return on the investment.

Actual examples of shop arrangements can be studied to advantage; in fact, a designer of a new shop should make himself conversant with existing plants, and thus make every effort to improve present practice. Advances in any art are usually made step by step, and progress in the right direction can be made with much more certainty if there is a familiarity with the ground already covered by others.

The shop arrangements described in this paper are examples taken from recent practice. None of the plans are advanced as "ideal," but each one is the result of at least twenty preliminary studies, and the reasons for their selection may be of interest. In two cases the shops are not yet built and, therefore, their location cannot be disclosed.

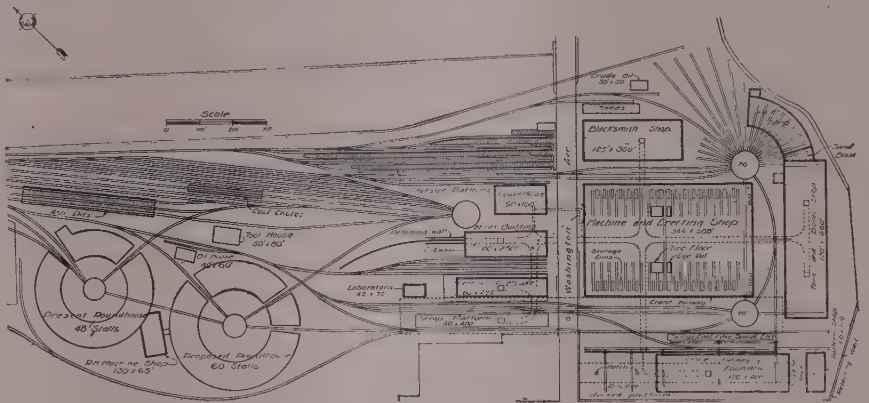


Fig. 12. Proposed Arrangement "A" of New Shops.

In this arrangement, the boiler and tank shop are separated from the machine and erecting shop, and two turntables have been located to facilitate the transfer of boilers and other material from one department to another. The disadvantage of the open pits will be overcome by extending the decking of the turntable over the entire pit.

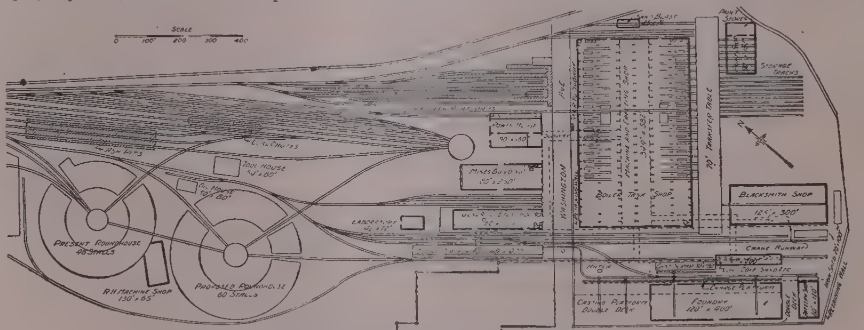


Fig. 13. Arrangement "B" of New Shops; Adopted-

In this arrangement the machine and erecting shop is served by means of a transfer table extending along one side of the shop. The boiler and tank shop is located in the extension to the main shop, it being the intention to maintain the same sections of the building throughout.

1. *Ivorydale Shops, Cincinnati, Hamilton & Dayton Ry.* These shops were designed to provide facilities for the storage and care of locomotives lying over at Cincinnati between trips and also for the necessary light running repairs upon engines running in and out of this division point. This shop is, therefore, an example of a terminal locomotive repair plant to take care of "light" repairs only as an auxiliary to the main repair shop where all "heavy" repairs are made.

The unique feature of this arrangement is the longitudinal engine house, sometimes called a "square round house." This engine house is served by the same transfer table that serves the erecting shop, the two buildings being directly opposite one another across the transfer table pit. The yard tracks form a "Y," thus obviating the necessity of a turntable. Incoming engines pass onto the transfer table, over one of two ash pits. There is one outgoing track. Engines can take coal and water either on the way in or out.

The engine house is built of reinforced concrete, and is designed for simply the care and storage of locomotives—no drop pit being provided on the engine house side of the transfer table. The machine and erecting shop has two drop pits in a separate section devoted to light repairs, while the erecting shop proper has a drop table to unwheel engines undergoing more extensive overhauling. One track without a pit is reserved for boiler repairs, which has sufficient space to work on two boilers at one time.

This arrangement makes the most economical use of the space available. It would have been impossible to have introduced the usual turntable plan with a round engine house on the property.

2. *Oaklawn Shops, Chicago & Eastern Illinois R. R.* The remarkable thing about this plan is that in 1904 the first machine and erecting shop was built with fourteen pits, and the provision made for doubling the shop was considered to be ample for years to come. In 1907, however, the shop was doubled, a fact which emphasizes the necessity for allowing ample room for growth.

In this plant the locomotive department may be said to have been grouped around the engine house, from which a shop track running between the machine shop and the boiler shop leads directly onto the transfer table, thus providing a convenient means of transportation to and from all departments.

The coach shop and the paint shop have not yet been constructed, but eventually the transfer table will also serve these two buildings of the car department.

The boiler shop is separate from the machine and erecting shop and is served by the same transfer table. The blacksmith shop is convenient to the car repair tracks, as well as to the round house and machine shop. The store house is central and handy to the main line.

The power house is located between the two departments and serves the locomotive shop through a pipe tunnel that connects all departments.

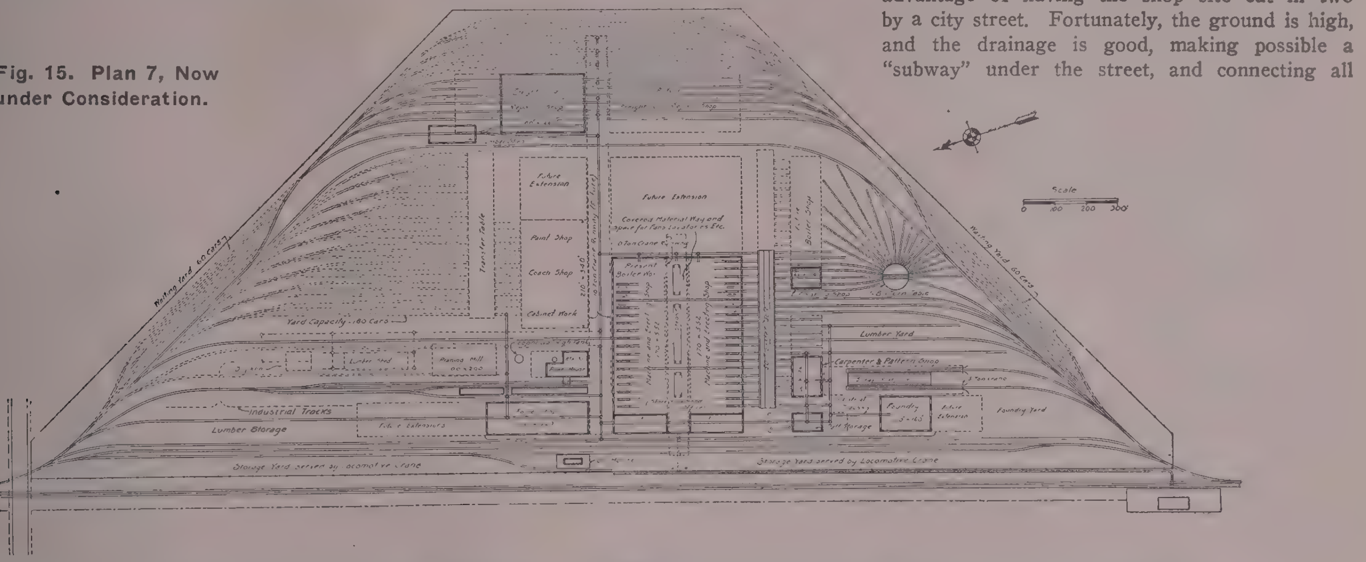
Too little space was originally allowed in the machine shop for machine tools, but this defect has been remedied to a certain extent in the recent additions. The general layout has proven so satisfactory in actual use that recently the management has had under consideration the reproduction of the entire plant at another point on the system.

In the main shop of this plant the larger individual motor driven tools are located in the erecting bay, that is made extra wide for this purpose. The disadvantage of this arrangement is the necessity of increasing the span of the traveling cranes and thereby adding to their cost.

3. *Battle Creek Shops, Grand Trunk System.* The distinguishing feature of this arrangement is the efficient use of the yard crane idea, extending over the store house tracks and part of the store house platforms. This crane serves all of the ends of the bays of the machine and erecting shop; the foundry, forge shop and frog shop, and eventually can be extended over the car repair tracks.

The "midway" space under the crane, which will be used partly for storage of materials, is provided with a system of industrial tracks, which are a part of a net work extending throughout the entire plant.

Fig. 15. Plan 7, Now under Consideration.



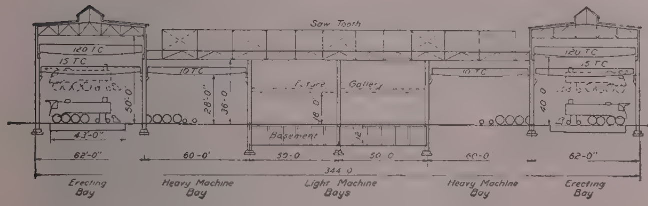


Fig. 14. Cross-Section of Shops in Fig. 13.

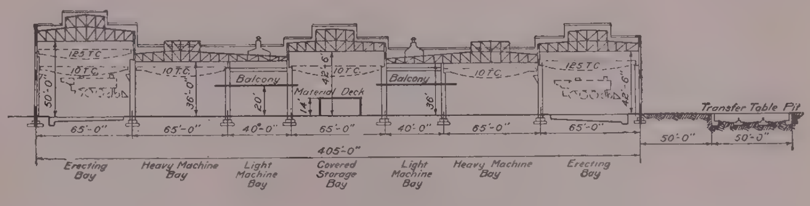


Fig. 16. Cross-Section of Shops in Fig. 15.

The boiler and tank shop in this arrangement are located at one end of the machine and erecting shop, but these departments are at right angles to one another, so as not to interfere with the entire plant being doubled at some future date. Ample openings are left in the wall between the boiler and the erecting shops, so that a boiler can be conveniently passed from one department to another.

The 100 per cent. extension to the main shop will be accomplished by practically duplicating the present shop, leaving a common machine shop twice the size of the existing one between two parallel erecting shops. This arrangement will eventually provide for fifty erecting pits, and all departments can be extended to meet this maximum requirement.

For the present time the locomotive shop will be served by two tracks, but when extensions are made two turntables can be installed.

4. *Beech Grove Shops, Big Four System.* In this layout even more extensive use has been made of the idea of a storage yard served by a high-speed overhead crane. The midway may be said to be the main avenue of travel between all departments, and the space between the buildings can be compared to side or cross streets. This crane serves practically every building except the tank shop, the wheel shop and the freight car repair shop, but all of these shops can be reached easily by industrial tracks.

The second feature of importance in this arrangement is the turntable serving the boiler shop, the tank shop and the main shop of the locomotive department. Tracks have been provided into each of these buildings independent of this turntable, but for intercommunication or the transfer of parts from one department to another this turntable will be in constant demand.

This turntable arrangement was adopted after the most careful consideration of an alternative plan having a transfer table along each side of the main shop, with the boiler shop on the opposite side of one transfer table, and the tank shop on the opposite side of the other table.

On one side of the yard crane nearly all the buildings extend away from the runway, thus allowing for future extension, while on the other side of the crane the buildings are arranged with their greater length parallel to the main line of travel. The freight car repair department is located along the main line tracks and convenient to the classification yards.

5. *Springfield Shops, Frisco System.* In this arrangement the yard crane is a prominent feature, and the midway and cross street idea has been developed still further, as all buildings are at right angles to this main avenue of interdepartment travel.

The striking feature of the Frisco shop arrangement, however, is the use of the transfer table serving one side of the erecting shop only. The erecting bay next to the transfer table is "single decked," i. e., the heavy crane used for unwheeling locomotives is not placed on an upper runway, so that it will be impossible to lift one locomotive over another in this shop, and reliance must be placed in the transfer table to put the locomotives on their pits.

Eventually, however, when the shop is doubled the future erecting bay on the other side of the shop will be "double decked," and the locomotives will be delivered to their respective pits on this side of the shop by an overhead 120-ton crane, instead of by a transfer table. When the shop is extended to its full capacity, no doubt the transfer table side of the shop will be devoted largely to light repairs, and the double-decked crane served side will take care of the heavier repairs.

The store house is at one end of the transfer table, and near the center of the yard crane runway, so that material can be conveniently collected from or delivered to any building on the ground.

The power house is located exactly in the center of the site. Every department can be increased at least 100 per cent. without unduly extending the lines of travel for men and material.

6. *Arrangement of Shops Under Construction.* The arrangements indicated in Figs. 12 and 13 are good examples of shops located on a congested site, which makes it impossible to secure an efficient layout of buildings, or make any liberal allowances for future extension. The advantage of locating the shop plant near the center of the city, however, is thought to offset the disadvantage of having the shop site cut in two by a city street. Fortunately, the ground is high, and the drainage is good, making possible a "subway" under the street, and connecting all departments. This feature adds much to the convenient handling of materials.

The yard crane is again the determining feature of the arrangement, serving nearly all departments and arranged to take or deliver material from and to the subway, and also the street, which fortunately is on a grade, so that it can be bridged.

The location of the foundry was determined by the fact that this department was the only one which could be placed along the retaining wall, which incloses part of the site. The heavy cranes in the erecting shop and the steam hammers in the forge shop make it desirable to locate these latter departments on solid ground.

The transfer platforms, one round house, and the accessory ash pits and coal chutes were in place at the time the new shop arrangement was taken up, but even with these handicaps, a fairly satisfactory arrangement of buildings has been worked out.

7. *Arrangement of Shops Under Consideration.* The layout of shops indicated in Fig. 15 is now under consideration and provides for a complete locomotive repair shop combined with a proposed terminal car repair plant. The main car department is located elsewhere.

This plan shows a crane served covered yard extending through the center of the main shop. This yard is not to be heated, and besides furnished storage facilities for material, it will provide a convenient location for fan rooms, toilet rooms, locker and wash rooms, which often occupy valuable room inside the shop.

The outside storage yard is served by a locomotive crane instead of an overhead crane, and this same locomotive crane can be used at all other points in the yard where it can be worked to advantage.

The transfer table serves one side of the machine and erecting shop, as in several of the other plans, two cross tracks being provided to transfer engines in and out of the erecting bay on the further side.

As the main shop becomes crowded it is possible to erect a separate boiler and tank shop along the transfer table, as shown, but for the present all locomotive repair departments will be under one roof.

The usual precautions have been taken to locate the blacksmith shop and the power house convenient to all departments.

The cross section of the main shop, indicated in Fig. 16, shows the covered yard between the two shops as well as the transfer table serving one side of the building.

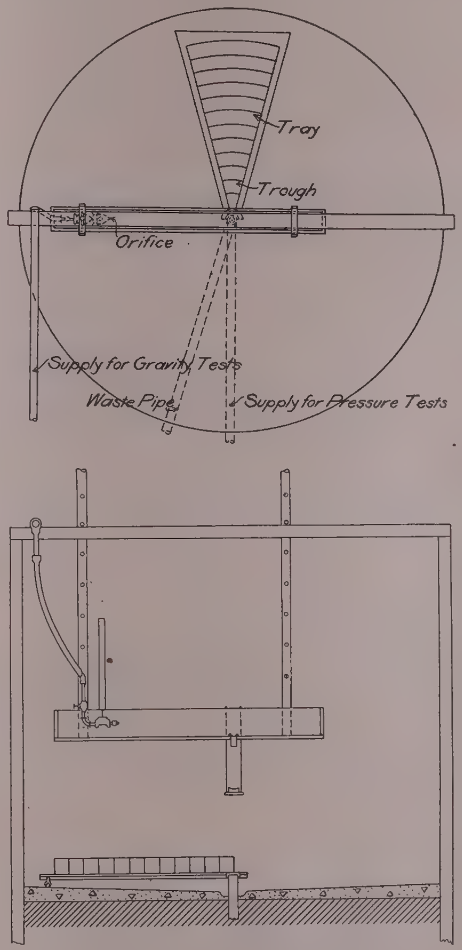
Will the results to be expected with new shops justify the investment? This is a question very often asked, particularly in view of the fact that apparently some of the new shops are not showing any better economy, as far as actual cost of locomotive maintenance is concerned, than is obtained with comparatively older and poorly equipped shops. As a matter of fact, there is no reason why a new shop handicapped with an undeveloped organization and a lack of an efficient system, should do any better work, or even as good, as an old shop with a harmonious corps of workers equipped with a full complement of jigs, templets and methods of operation.

The logical developments in cutting down the cost of engine repairs upon any road would appear to be (a), make the best use of the repair equipment at hand by perfecting shop kinks and systems for handling the work adapted to the outfit available; (b), to wear out the old tool equipment in the old shop as far as possible, so that when the building of the new shop cannot be postponed longer, there will be little, if any, temptation, to economize by using the old tools; and (c), with the coming of the new shop, old methods of operation should be improved to fit the changed conditions, and new systems developed and adopted. A new shop should not be considered complete until every man, tool, accessory and system is doing its most effective work. Under these conditions the new shops will show ample results to justify the investment.

THE SHIRE HIGHLANDS NYASALAND RY., in Africa, is being constructed to afford communication between Port Herald, a river port on the Shire River, tributary to the Zambesi River, and Blantyre, the capital of the British Central Africa Protectorate. The Zambesi and Shire are by treaty international rivers, but navigation is much obstructed by shoals, and Blantyre is at present practically isolated six or eight months in the year. The road has a gauge of 3 ft. 6 in. and is laid with 41¼-lb. rails fastened to steel ties. From Port Herald the line is parallel to the Shire River for 30 miles to Chiromo, where the river is crossed by a temporary bridge to be replaced later by a 350-ft. steel bridge on screw piles with a 100-ft. lift span. Here the route leaves the Shire and follows a very tortuous course for the remaining 82 miles, the ruling grade being 1 in 44 with minimum curves at 363 ft. radius. Many mountain streams in deep gorges are crossed. The summit of the line is 2 miles from Blantyre where the elevation is 4,000 ft. above sea level. The consulting engineers are Sir Douglas Fox & Partners and Sir Charles Metcalfe.

Sewage Distributors for Sprinkling Filters.
Part I.

The methods of distributing sewage evenly and at the proper rate over the surface of a filter has received a great deal of attention, but there is no unanimity of opinion concerning the apparatus to be used. Fixed troughs, of which the Stoddart distributor is a type, revolving arms, such as the Candy-Whittaker apparatus, traversing or revolving troughs, like the Scott-Moncrieff distributor, and fixed nozzles for spraying the sewage, have been illustrated in this journal from time to time, and have their earnest advocates. Another type, by which a sort of gravity distribution is obtained, was devised at the Sanitary Research Laboratory of the Massachusetts Institute of Technology about three years ago, and has given satisfaction there. The sewage is distributed in troughs above the filter, from which it drops through holes in the bottom of the troughs onto concave disks below, splashing upward from the disks in a fine spray. In order to settle a number of doubtful points concerning some of these methods of distributing sewage, a number of investigations have been made at the Sanitary Research Laboratory, and a detailed report of them, by Messrs. C. E. A. Winslow, Earle B. Phelps, C. F. Story and H. C. McRae appears in the "Technology Quarterly," from which the following notes have been taken:



Apparatus for Sprinkler Tests.

The Stoddart distributor and the various types of movable sprinklers used in England are theoretically perfect, and their failure, when it occurs, is due to structural imperfections or lack of care in maintenance. On the other hand, fixed sprinkler nozzles and the gravity system of distribution cover at best only a portion of the surface of the filter. Since both these latter types discharge sewage approximately in a circle, each nozzle or disk will wet only 78 per cent. of the square area surrounding it. Furthermore, almost all these distributors tend to discharge, for the most part, in one or two concentric rings of the wetted area. Some nozzles, too, discharge unevenly along different radii. It is important to determine how serious these deviations are. Imperfect distribution means that a part of the filter area below is wasted and another part is operated at excessive rates. Yet almost no exact data upon this point are now available. Some experimenters have noted the proportion of the total area wetted by their sprinklers; but such a standard fails to discriminate the extent of the discharge upon different portions of the wetted area.

For the quantitative study of the efficiency of distribution a measuring apparatus was devised, the construction of which is indicated in the illustrations. It consisted of a shallow, circular basin of concrete 14 ft. in diameter, sloping toward a central drain connected with a waste pipe below. A 2-in. supply pipe passed under the concrete and rose through this drain at the center of the basin. To this pipe were attached the sprinkler nozzles of various types designed for pressure distribution. A wooden platform in the shape of the 30° sector of a circle was attached at its pointed end to a 2½-in. iron collar, fitted over the supply pipe so as to turn freely upon it. The outer end of the wooden platform was supported on ball-bearing castors, arranged to run on a flat shelf at the periphery of the concrete basin, so that the whole platform could be revolved about the supply pipe as a center, and the collar and castors were so adjusted that the platform was exactly level. The platform carried a galvanized iron tank, also in the form of a 30° sector, divided into compartments by concentric arcs 6 in. apart. The radius of the tank was 6 ft., giving twelve concentric compartments, and its depth was 6 in. When this tank was rotated about the supply pipe during the course of an experiment, the evenness of distribution was, of course, measured by the relative amount of liquid collected in the respective compartments. In various stationary positions the trough recorded radical inequalities.

The supply pipe at the center of the basin was connected at its outer end with an upright stack of 2-in. pipe, made up of short lengths, any desired number of which could be used. At the top of the stack was a wooden box, fed by a hose and relieved by an overflow just below the top. The difference between the water level in this box (varied by removing sections of pipe from the upright stack) and the level of the sprinkler nozzle at the center of the basin represented approximately the total head effective in distribution. The rate of flow was, of course, fixed by the head and the sprinkler nozzle used. It was estimated in each test from the total discharge into the measuring tank, and from the time occupied by the run.

The apparatus was adapted for the study of gravity distributors by the addition of an overhead trough. This was hung from two timbers passing diametrically across the basin, supported at their extremities by upright studs. At a point fixed over the center of the apparatus a ¾-in. brass orifice in the bottom of the trough allowed the liquid to discharge upon the splashing disk below.

The uprights supporting the trough were fixed to the cross-timbers above by movable iron pins, and the uprights were pierced for the reception of these pins at intervals of 1 ft., so that the distance between the trough and the measuring tank below could be varied at will. The distance between the level of the water in the trough and the top of the tank measured the total head available for gravity distribution. In this system, however, there is another variable. With a given total head, the distance between the point of discharge and the splashing disc and the distance from the splashing disc to the filter may be mutually varied. In the experiments this was provided for by supporting the various splashing discs tested upon a circular lead plate, 6.5 in. in diameter, hung from the distributing trough by four wires. Varying the length of these wires altered the portion of the total head above the splashing disc (called for convenience "head-on-sprinkler").

The rate of flow with this type of distributor is, within limits, independent of the head, so that the rate also had to be taken into account. The rate of discharge was equal to the rate of supply of liquid to the trough, and this supply was measured through a calibrated orifice. Two orifices were used in the experiments, one 7-16 in. and one ⅝ in. in diameter. The orifice plug in use was connected to a 2-in. tee by a reducing coupling. The section of the tee was large enough to permit an accurate measurement of the static head on the orifice by a glass piezometer tube inserted in its top, and the head was adjusted at any desired point by a valve behind the tee.

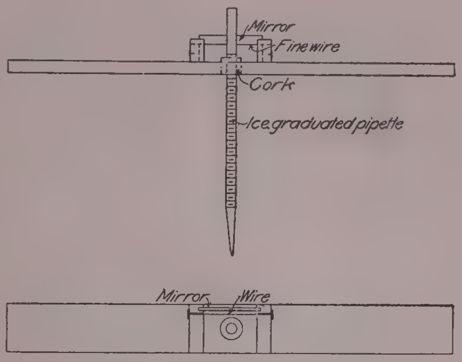
Discharges of 1.71 and 4.08 gal. per minute, corresponding to 5-in. and 36-in. heads on the orifice, were chosen as two arbitrary rates of discharge for the gravity distributor tests. The ⅝-in. orifice was tested sufficiently to find a third, higher rate. A head of 18 in. on this orifice was found to give a discharge of 1.1325 cu. ft., or 8.47 gal., per minute, and this was used as the standard rate for high discharges. The entire apparatus was protected during the course of the experiments by a rough wind shield.

The measurement of the volume of liquid collected in the various compartments of the measuring tank during a test was, according to the original plans, to be made directly, and for this purpose a small stopcock was attached to each compartment. This process proved somewhat tedious, however, and the same end was attained by measuring the depth of the liquid in each compartment at the end of the run, after a careful preliminary calibration of the various compartments.

The depth of water in this measuring tank, and in the cypress tank used for nozzle calibration, was measured by a simple and accurate gauge devised for the purpose, the construction of which is indicated in an illustration. It consisted of a graduated glass tube (a 1 c.c. pipette), the graduated portion being 6 in. long and divided into hundredths. This tube slid up and down in a cork fitted into a long, flat piece of wood, carefully planed. When the wooden crosspiece rested in a horizontal position, supported at its ends, the tube between was exactly vertical. Just above the wooden crosspiece a fine wire was stretched longitudinally between two supports behind the tube, and behind the wire a small mirror was fixed. By reading with the wire and its reflection superposed the position of the tube could be estimated to tenths of its smallest graduations (0.0005 ft.). In measuring the depth of water in a compartment of the measuring tank the wooden crosspiece of the gauge was rested on the two sides of the tank, and the tube was slid carefully down till its mouth just touched the surface of the water. This point could be detected with great accuracy by the jump into the tube of the drop of water drawn up by capillary action.

Each compartment of the measuring tank was calibrated by pouring in measured quantities of water and reading the depth after the addition of each successive portion. The average of these determinations gave the number of units of depth corresponding to a given volume of water. The reciprocal of this was the volume of water corresponding to a unit of depth for the compartment in question. A special correction was necessary for irregularities in the bottom of the tank and for the zero reading of the gauge. The former was determined by the difference between the change in level produced by the first portion of water poured in and by subsequent portions.

In beginning a run the measuring tank was emptied, put in place on the wooden platform and covered with a cover of tar paper stretched over slats. The desired total head was adjusted by raising or lowering the trough, and the head on the sprinkler was regulated by means of the wires suspending the lead plate from the trough. The disc to be tested was then centered on the lead plate just below the ¾-in. opening in the bottom of the trough. The valve supplying the trough was then opened and regulated till the desired discharge was registered on the piezometer tube. After conditions had become constant in the trough, the cover of the measuring tank was removed (the time being taken with a stop watch). During the test the tank was slowly rotated by hand. As soon as any compartments became so full as to threaten splashing the test was stopped, the cover replaced, and the time again noted. The supply valve was then closed, and after the discharge had ceased the cover was removed and the depth of liquid in each compartment of the measuring tank was determined, as described above.



Construction of Gauge,

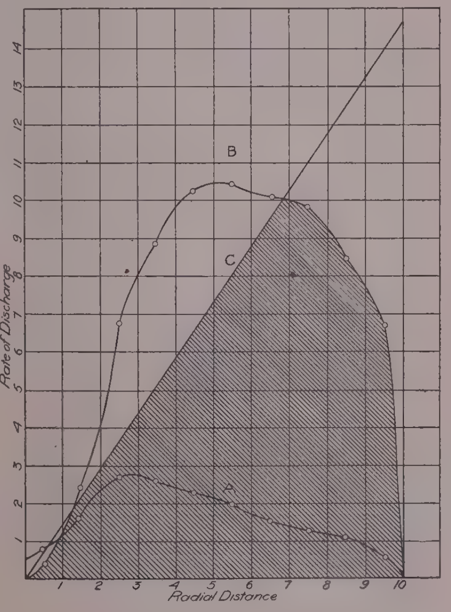


Diagram of Distribution.

Coefficients of Distribution. After the proportionate amount of discharge in various zones about the distributors had been determined by the method outlined above, it was necessary to devise some method of stating the results so that the efficiency of the various types could be easily and accurately compared. For this purpose Prof. Phelps has derived a "coefficient of distribution," which shows the mathematical relation between any observed condition of distribution and that ideal condition in which each small unit of area should receive its exact proportionate share. Professor Phelps' calculations were published in the "Technology Quarterly" for March, 1907. The following quotation outlines his method:

"For the purposes of this problem let us assume that a pressure sprinkler is shooting up a spray of sewage fountain-wise, the sewage falling over a circular area. Along any radius let us place a line of small, square collecting tanks of known areas, which we may designate the unit area. Let it be assumed, further, that the distribution along this radius is the mean of that along all radii. The variations along the various radii will be small, and the assumption may be completely realized, as is being done in our experiments, by revolving the line of collecting tanks about the center during the experiment. After running a suitable length of time the sewage is shut off, and the amount collected in each small tank is measured. In the accompanying table a set of actual results is reproduced for the sake of illustration.

RESULTS OF OBSERVATIONS OF DISTRIBUTION EFFECTED BY SEWER SPRINKLER.

Tank.	Radial distance (D).	Sewage quantity (Q).	$D \times Q$.	Excessive quantities (Ex. Q.)	$D \times$ Ex. Q.
1	0.5	0.8	0.4	..	..
2	1.5	1.6	2.4	0.14	0.21
3	2.5	2.7	6.8	1.24	3.10
4	3.5	2.5	8.8	1.04	3.65
5	4.5	2.3	10.3	0.84	3.78
6	5.5	1.9	10.4	0.44	2.43
7	6.5	1.5	10.0	0.04	0.26
8	7.5	1.3	9.8	..	..
9	8.5	1.0	8.5	..	..
10	9.5	0.6	5.7	..	..
Totals ..	50.0		73.1		13.43

$$73.1 \div 50.0 = 1.46 = M.$$

"In the first column are given the numbers of the collecting tanks, No. 1 being at the center. In column 2, headed *D*, are given the distances from the center of the sprinkler to the centers of the corresponding tanks, the side of the tank being taken as unit distance. In the third column, *Q*, are given the amounts of sewage measured in each tank at the end of the test. Any unit of volume may be employed. In this case the depths in the measuring tanks are used, these being proportional to the volumes. Now, if these quantities, *O*, are plotted as ordinates against the corresponding *D* values as abscissæ, we obtain a curve showing the relative distribution of the sewage along the radius. This curve is shown at *A* in the diagram. It shows the rate of discharge per unit area at any point whose distance from the center is known, and will be known as the curve of radial distribution. Since the radial distribution measured was assumed to be the mean of all radial distributions, the ordinate of this curve at any given distance from the center shows the rate of discharge at all points on a circumference described about the center at the given distance from it. Hence to obtain a curve showing the distribution on the whole circle, *i. e.*, on an infinite series of successive circumferences, it is necessary to multiply the ordinate for each point on the radius by the length of the corresponding circumference, or what amounts to the same thing, relatively, by the radial distance of the point in question. In column 4, $D \times Q$, in the table are given the figures resulting from this operation. These quantities represent the relative rates of discharge of the sewage upon successive concentric rings of the circle, the width of the rings being unity and their distances from the center being the corresponding *D*. If now a new curve be plotted with these products just obtained as ordinates and the corresponding *D* values as abscissæ, the resulting curve is the curve of distribution over the wetted area (curve *B* in the figure).

"From its construction this curve has the following properties: The ordinate at any point shows the relative rate of discharge of the sewage upon a circumference at the corresponding distance from the center; the area of any vertical strip shows the relative total discharge upon the corresponding ring of the wetted circle; and the total area under the curve represents the total discharge from the sprinkler.

"It will next be necessary to construct the curve of perfect distribution. This curve must conform to the fact that the discharge upon all unit areas is the same, and hence that discharges upon all circumferences are directly proportional to their depths, *i. e.*, to their radii. Obviously, then, the curve is a straight line passing through the origin. Its slope is determined graphically by the fact that the area under the curve represents the total discharge from the sprinkler, and hence equals the area under the distribution curve already drawn. The latter area may be determined by means of a planimeter, and from the known base of the triangle its altitude may be computed. It may be calculated more readily but less accurately by adding up the column $Q \times D$, and dividing by the radius of the wetted circle (10). This curve is shown in the figure as curve C.

"We now have the curve of actual distribution and the curve of perfect distribution. There remains to be derived a mathematical expression of the relation between these two curves. The curves have a common area, which is shaded in the diagram. From what has preceded it will be apparent that the more perfect the distribution the more nearly will the two curves coincide, and the greater will be this common area. Hence a direct comparison of the common area with the total area of either curve gives a numerical expression of the efficiency of the distribution. If the distribution be perfect the two curves will coincide, and the ratio, common area to total area, will be unity. If the distribution is very poor the common area will be small, in proportion to the total, and the ratio will be correspondingly low. Moreover, while it is not so evident from the present brief description of the method, a more careful analysis of the mutual relations of these two curves shows that two distribution curves differing from one another in shape, but yielding the same ratio of common area to total area, represent conditions actually different, but identical as regards relative distribution.

"If we define the term 'excessive discharge' as that part of the discharge from a sprinkler which is flowing upon any area of the filter in excess of the mean rate for the total area (represented graphically by that portion of the area above the straight line), then we may define the coefficient of distribution as the ratio of the total discharge minus the excessive discharge to the total discharge; or, in algebraic form,

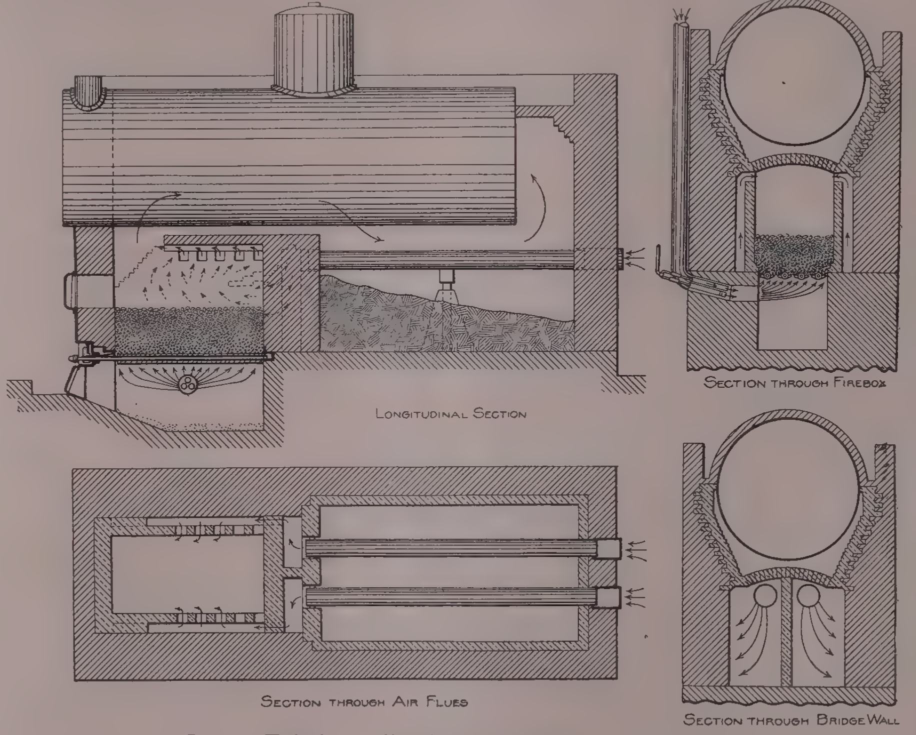
$$\text{Dist. Coef.} = (T - E) \div T$$

or, more simply,

$$\text{Dist. Coef.} = 1 - E/T$$

"Comparisons of the areas may be made quite readily by means of the planimeter. To obviate the necessity of multiplying to get the quantities $Q \times D$, a special form of plotting paper has been used, which performs the multiplications graphically. This paper has one set of co-ordinate lines vertical, as usual, and the other set radiating from the origin. Direct plotting of the figures used in curve A upon such paper will in reality give curve B, any given value having an actual magnitude upon the plot which is proportional to the horizontal distance from the origin."

While the plot and the foregoing demonstration are essential to a clear understanding of the coefficient, it has been found much simpler and sufficiently accurate in practice to make an arithmetical calculation of the coefficient directly from the observed data. Either the gallons in each compartment of the measuring tank, per unit change in depth, or the relative area of the compartments, may be used instead of column 2, D, in the table, since it corresponds to it, with an allowance for the irregularities of construction in the tank. For column 3, Q, the observed depth is used, after the application of the proper bottom correction. The sum of the fourth column, $D \times Q$, gives the total discharge, T, upon the sector tested, directly in gallons, if the relative value in gallons is used for D. The sum of column 2, D, corresponds to the total wetted area; that is, it bears the same relation to the total area that the sum of the fourth column, $D \times Q$, does to the total discharge. In practice, when the liquid discharged did not reach the outer compartments, those zones not wetted were, of course, omitted from column 2. Now, if the sum of column 4, $D \times Q$, be divided by the sum of column 2, D, the quotient, M, will be the mean discharge per unit area over the whole wetted surface. If this mean discharge be subtracted from each value of Q, which is greater than the mean, a set of figures are obtained which are shown in the table in column 5, under the heading Ex. Q. These figures are the excessive discharges per unit areas at the respective distances from the center. Multiplied again by the distances in the D column, they give the excessive discharges for the concentric rings, and the sum of the latter figures, column $D \times$ Ex. Q, gives the total excessive discharge, as already defined, E. In practice, the difference between the mean discharge and the actual discharge was also determined for the zones which received less than their share; and the sum of these values was used as a check on the total excessive discharge, E.



Return Tubular Boiler Setting for High Volatile Coals.

Either the total excessive discharge on the areas receiving too much liquid, or the total deficient discharge on the areas receiving too little, when divided by the total discharge, measures the deviation of the distribution from a perfect condition. Referring to diagrams of distribution, it will be seen that the total discharge, T, corresponds to the area under the line C, and that the excessive discharge, E, corresponds to the area below B and above C. Perfect distribution would be indicated by a value of zero for E or a coincidence of lines B and C. This condition is called unity, and the observed condition in any case is expressed as the difference between unity and the ratio of excessive discharge to total discharge. In the shape of a formula this becomes,

$$\text{Dist. Coef.} = 1 - E/I$$

and in the illustrative example given in the table, $E = 13.4$, $T = 73.1$, $c = 1 - 0.18 = 0.82$.

The crude coefficient thus derived refers to the efficiency of the sprinkler under the given conditions and figured upon the area of the wetted circle. There remains to be derived the true corrected coefficient based upon the total area of the filter, including the unwetted corners between the circles. Each wetted area should be referred to the area of a square whose side is the distance between centers of adjacent sprinklers. Denoting the area of the square by Sq. and of the wetted circle by Cir., the corrected coefficient, C, may be found from the crude coefficient, c, by the formula,

$$C = c \times \text{Cir/Sq.}$$

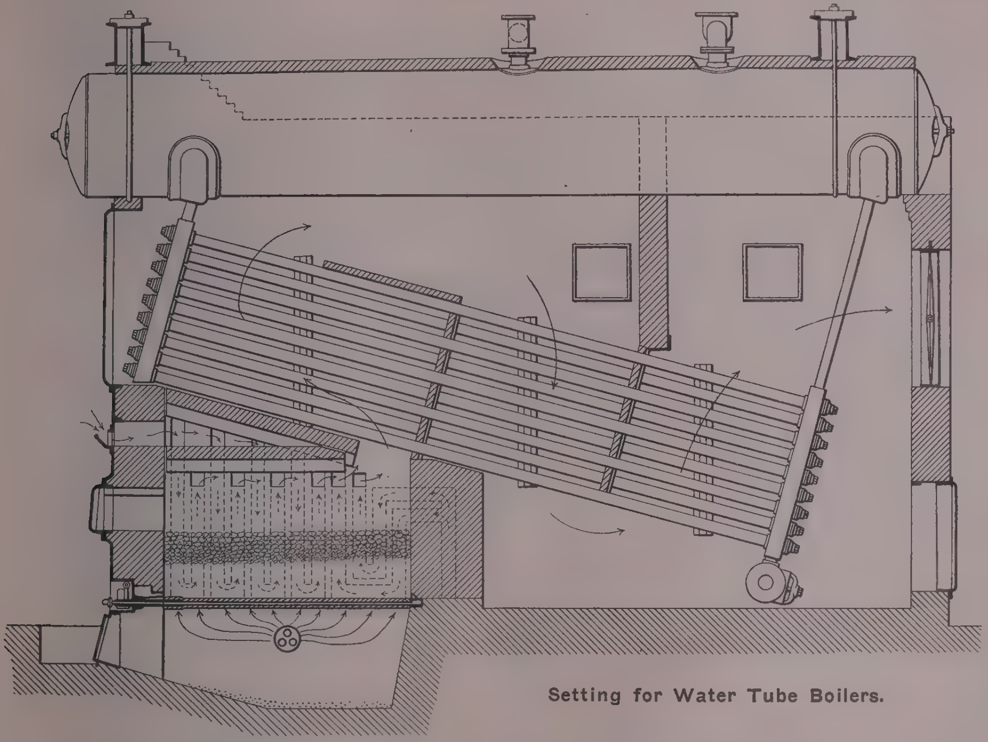
This correction will, of course, diminish the crude coefficients to less than 78 per cent. of their value for the wetted area, and all coefficients recorded in the investigation are calculated upon this basis of arrangement in squares. In practice, however, it would be of advantage to arrange distributors, not along two axes at right angles to each other, so that each is at the center of a square, but on three axes inclined at 120°, so that each is at the center of a hexagon. With distributors at the centers of squares, the waste area, with no overlapping, amounts to 21.5 per cent. of the whole. With distributors at the centers of hexagons, the waste area amounts to only 9.9 per cent. The hexagonal arrangement makes it possible to put 343 sprinkler heads on an acre instead of 303, spaced with 12 ft. between centers, and to raise a rate of 2,000,000 gal. to 2,270,000 without increasing the discharge upon any portion of the wetted area.

(To be Continued.)

Luminous Electric Heaters have been installed in 27 rooms of the Eagle Hotel, Grand Rapids, Mich., as an auxiliary to the steam heating system, the idea being not only to secure more heat but also to make the rooms more pleasant by the glow of the heaters, which were made by the General Electric Co. Current is supplied for them at 3 cents per horse-power-hour by the Grand Rapids-Muskegon Power Co.

A Boiler Furnace for Burning High-Volatile Coals.

A boiler furnace specially adapted to burning high-volatile coals, such as the lignites abundant in the Rocky Mountain region, has been introduced in that section of the country during something over two years. This furnace embodies an application of the gas-producer method of burning coal. First, a fuel bed about 24 in. deep is kept in various stages of combustion from a live fire at the surface down to dead ash on the water-cooled rocking grates that carry it. By introducing into a sealed ash pit, by means of a steam jet, only sufficient air to burn the fixed carbons in the coal, the gas-producer effect is obtained. The rapid burning of the fixed carbon produces a high temperature in the fire box, so the volatile carbons are not cooled and little or no smoke is produced. The additional oxygen required to consume the large volume of gas generated in this manner is supplied over the fire through air ducts in the side and bridge walls of the furnace, entering the latter in such manner as to mix with the gases as they rise from the fuel. This air cools the walls of the fire box as it enters and is preheated before it reaches the combustion chamber. The gases, therefore, are never exposed to wholly cool surfaces, or to currents of cold air after they have been generated, until combustion is practically complete.



Setting for Water Tube Boilers.

These principles produce a long, intense flame, and no claim is made that they are original discoveries, but the mechanical difficulties involved in their application have heretofore not been solved in this way. Furnaces of this type have, nevertheless, been installed in the Western part of the country under practically every style of return-tubular and water-tube boilers, with, it is asserted, uniformly good results in fuel economy. The details of the arrangement of a typical installation of a furnace for both types of boilers are shown in accompanying illustrations. All furnaces of this type for return-tubular boilers are practically the same, but those for water-tube boilers have to be altered to some extent to suit the different forms of these boilers.

The furnaces for the return-tubular boilers are different in details only from the standard flat-grate furnace usually employed for boilers of this type, while the boiler settings are not changed in any way. The water-cooled rocking grates are quite simple in design, the sections being continuous the length of the furnace and arranged so they can be turned readily by hand from the front. The frame in which the grate sections are mounted is continuous with the frame of the ash pit door, the latter being built so it can be sealed to prevent the admission of air. The primary air, as the quantity admitted under the fire is designated, is supplied through a duct in the side of the ash pit. This duct connects on the outside with a riser extending above the roof of the boiler room. The flow of air in the duct is induced at the connection to the riser by jets of steam from three small nozzle openings. These steam jets supply sufficient moisture to keep the ashes damp at the bottom of the deep fuel bed and also furnish hydrogen to assist in the formation of gases. As the jets are entirely under control, the supply of primary air can be manipulated readily.

Aside from the deep fuel bed, one of the principal differences in the interior of the furnace from those of ordinary types is a brick arch placed across the furnace, directly under the boiler and between the side walls, extending from the bridge wall forward to within a short distance of the front of the furnace. The gases are thus directed to the front of the fire box and pass between the arch and the shell of the boiler without reaching any cool surfaces. The arch is thus exposed to extremely high temperature and its maintenance in the past has probably been the chief obstacle to an application of gas-producer principles to boiler furnace practice. The previous difficulties encountered from an arch of this kind have been overcome, however, by using different kinds of fire brick for different coals, each brick being refractive to the coal burned in the particular furnace. The arch is built of a single ring of these bricks laid up without mortar and where properly constructed in this manner has given no trouble from fusing.

The air admitted over the fire, or the secondary air, enters the boiler setting through a pair of wrought-iron tubes extending from the rear wall of the setting to the bridge wall, in the combustion chamber under the rear end of the boiler. These tubes are exposed within the setting to the long flame which continues over from the fire box, so the air as it passes through them is heated to a high temperature. Each tube connects with an air cell in the bridge wall, and these cells are connected in turn with ducts in the side walls of the furnace. Each of these side-wall ducts has a series of ports, through which the air enters the furnace from them. The secondary air required to produce the combustion of the gases generated by the rapid burning of the fixed carbons is thus heated and distributed.

The furnace used for water-tube boilers with inclined tubes and horizontal drums differs from the one just described chiefly in that the arch between the side walls extends from the front of the furnace toward the bridge wall, and the secondary air enters the boiler setting at the front through an opening just above the firing door. The usual arrangement of baffle-plates for a boiler of this type is also modified to some extent.

In all cases furnaces of this type are said to be fired with much less labor than is necessary to fire an ordinary furnace. The deep fire, the method of burning and the construction of the furnace preclude any necessity for cleaning the fire with open doors; the grates, in fact, are not generally shaken oftener than once in 8 to 10 hr., and then without difficulty.

Some of the results of operating furnaces of this type, as reported by the makers, indicate unusual efficiencies in burning lignite or high-volatile coals. For instance, in the power plants of five manufacturing concerns in Denver, Colo., burning lignite on flat grates, analyses of the ash showed the latter to contain an average for the five of 48.5 per cent. combustible, which, it is stated, may be considered a fair example of results obtained in that region. An average ash analysis from three plants in the Cripple Creek district, also having boiler furnaces with standard flat grates, but fired with run-of-mine bituminous coal, showed 40.8 per cent. combustible, while in four plants in the same district burning the slack lignite in these special furnaces, the average ash analysis indicated only 13.5 per cent. combustible. This saving is largely due to the fact that the lignite and many other coals in the region where these furnaces have been used disintegrate rapidly into small particles immediately on being placed in the furnace, with the result that on the standard flat grates much of the fine material is lost, while the deep fuel bed in the special furnace retains such fine material.

A comparative test between a standard flat-grate furnace using run-of-mine bituminous coal from Colorado and one of these special furnaces burning run-of-mine lignite coal was made under exactly similar conditions in the power station of the Golden Cycle Mining Co. at Goldfield, Colo., under the supervision of Mr. Herman R. Weber, mechanical engineer, and Mr. J. M. Purmort, master mechanic for the company. Both boilers were of the Cahall water-tube type, with a rated capacity of 264 h.-p. each. Two tests of the flat-grate furnace and four of the special furnace were made, the tests of the former having an average duration of 7½ hr. and of the latter of 6¾ hr. The steam pressure, feed-water temperature and stack draft were practically the same in both cases. The average temperature of the flue gases in the tests of the standard furnace was 578.5° Fahr., while the average stack temperature in the four tests of the special furnace was 488.8° Fahr. The factor of evaporation was 1.215, the water apparently evaporated per pound of fuel was 6.25 lb. and the equivalent evaporation from and at 212° Fahr. was 7.592 lb. for the standard furnace, as compared with 1.2037, 5.999 and 7.231 for the same respective values in the tests of the special furnace. Colorado bituminous coal was used in firing the standard furnaces and cost $5.35 a ton in the boiler room; run-of-mine lignite coal was used in firing the special furnace, however, and cost only $3.025 per ton. The cost of fuel per 1,000 lb. of water evaporated was 0.3523 cent per pound for the standard furnace, as compared with a cost of 0.2094 cent per pound for the special furnace.

A comparison made in the power plant of the Butte & London Copper Development Co. at Butte, Mont., gave similar results. The tests were made in this instance on a 125-h.-p. return tubular boiler, three tests being made with the special furnace and four with the standard flat-grate furnace. The average results of these tests are given in the accompanying table; other tests have been made in various power plants, with similar results. Among these is the plant of the Vindicator Consolidated Gold Mining Co. at Cripple Creek, Colo., where the special furnaces have been operated under three 267-h.-p. Babcock & Wilcox boilers since October, 1906, and under a 150-h.-p. boiler of the same make for nearly as long. The Golden Cycle Mining Co. also has twenty-one of the special furnaces serving seven 100-ton ore roasters in a mill near Colorado Springs, Colo., a flame as long as 70 ft. being produced for this purpose, such a flame formerly being considered possible only with the use of oil.

SUMMARY OF BOILER TESTS MADE FOR THE BUTTE & LONDON COPPER DEVELOPMENT CO.

Average of tests.	Flat Grates.	Special Furnace.
Number of tests	4	3
Equivalent of water evaporated from and at 212 deg. Fahr., per pound coal as fired	5.234	5.790
Pounds coal to evaporate 1,000 lb. water from and at 212 deg. Fahr.	191.06	172.71
Lignite mine run, at per ton	$5.35	—
Lignite slack, at per ton	—	$3.15
Cost of coal per 100 lb.	0.2675	0.1575
Cost of coal to evaporate 1,000 lb. water from and at 212 deg. Fahr.	0.511	0.272
Average efficiency, per cent.	52.75	64.76

The special furnace described is controlled by the Western Furnace Co., of Denver, Colo.

Tests of Alcohol and Kerosene as Fuel for an Oil Engine.

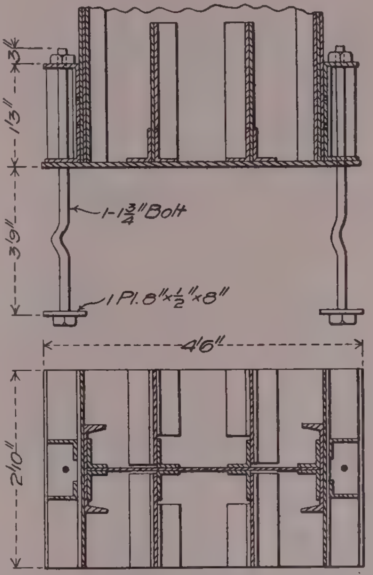
Alcohol and kerosene as fuels for a 6-h.-p. Mietz & Weiss oil engine have been tested by Prof. Lucke, in the mechanical engineering laboratories of Columbia University, with the following results: 1, To run the engine satisfactorily on alcohol it is necessary that the fuel injection mechanism be slightly modified. 2, When properly arranged for alcohol this engine can be started as readily and operated as satisfactorily on alcohol as on kerosene. 3, With kerosene it is aboslutely necessary to keep the bulb cool by some means, and the steam injection satisfactorily accomplishes this result. 4, With alcohol the bulb tends to become too hot and it would probably be advantageous to use some means for cooling it. 5, The maximum power obtainable from the engine with alcohol is greater than the maximum with kerosene. 6, The best consumption obtained with kerosene is 0.98 lb. per brake horse-power-hour. 7, The best consumption that was obtained with alcohol was 1.6 lb. per brake horse-power-hour.

Structural Features of the Warwick Shops of the Lehigh & Hudson River Ry.

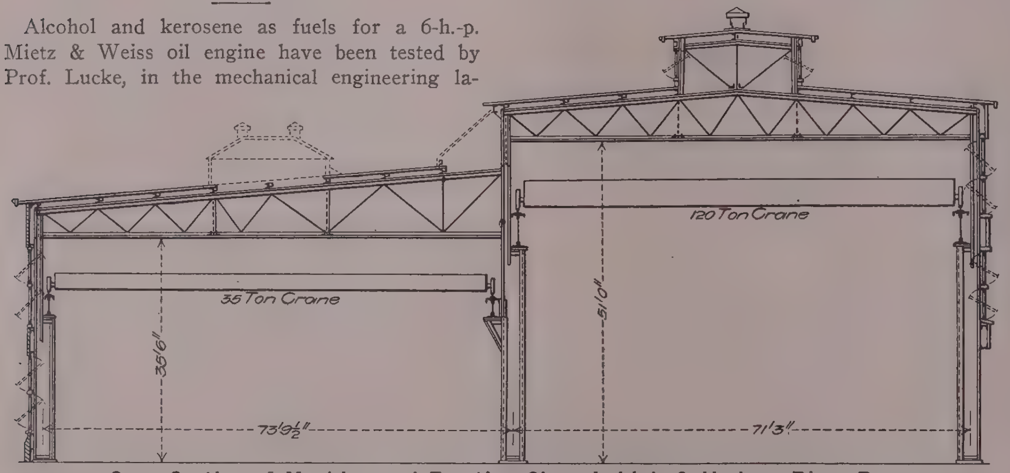
A 154 x 145-ft. steel and concrete building for locomotive repairs and general machine shop work has just been built at Warwick, N. Y., for the Lehigh & Hudson River Ry. Co. It was so urgently required that its construction was considered almost as emergency work, and was designed to afford immediate shelter for the necessary tools and power plant. Provision is made for future extensions on the lines of the original structure and when they are made the power equipment and blacksmith shop will probably be moved to separate buildings.

The present structure has two parallel 154-ft. aisles, having spans of 71 ft. 3 in. and 73 ft. 9½ in. respectively. These have steel roof trusses and struts supported by steel columns 22 ft. apart in three longitudinal rows. The 71-ft. 3-in. aisle has a height of 51 ft. clear from the floor line to the lower chord of the roof trusses and is used for repairing and assembling locomotives. It will be equipped with a 120-ton girder crane of 69½ ft. span commanding the entire length, and is lighted by a full-length monitor on the center line of the roof, by slant windows in the clere-story wall above the other aisle, and by a large area of windows in the side walls and end walls.

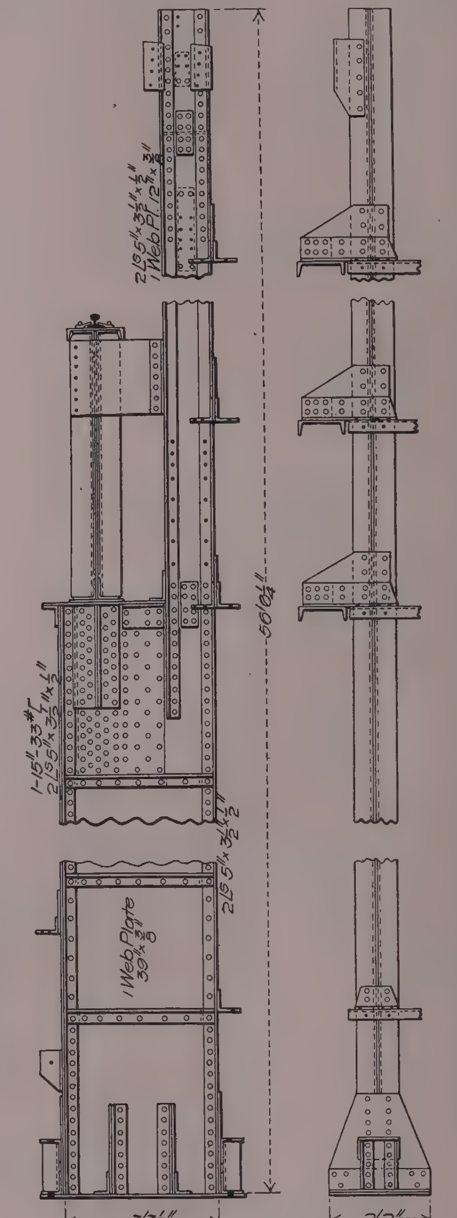
The 73-ft. 9½-in. aisle is the machine shop proper and has a clear height of 35½ ft. from the floor line to the lower chord of the roof trusses. The entire area is commanded by a 35-ton girder crane of 70-ft. 2-in. span and is lighted by a large area of windows in the walls and by one 11 x 18½-ft. hipped skylight in each roof panel. It is intended to install only a 35-ton girder crane in the erecting shop at first and, later, when it is replaced by the final 120-ton crane, to remove the former to the machine shop and adapt it to run on the track of slightly wider gauge by shifting the end trucks a few inches.



Column Base.



Cross-Section of Machine and Erecting Shop, Lehigh & Hudson River Ry.



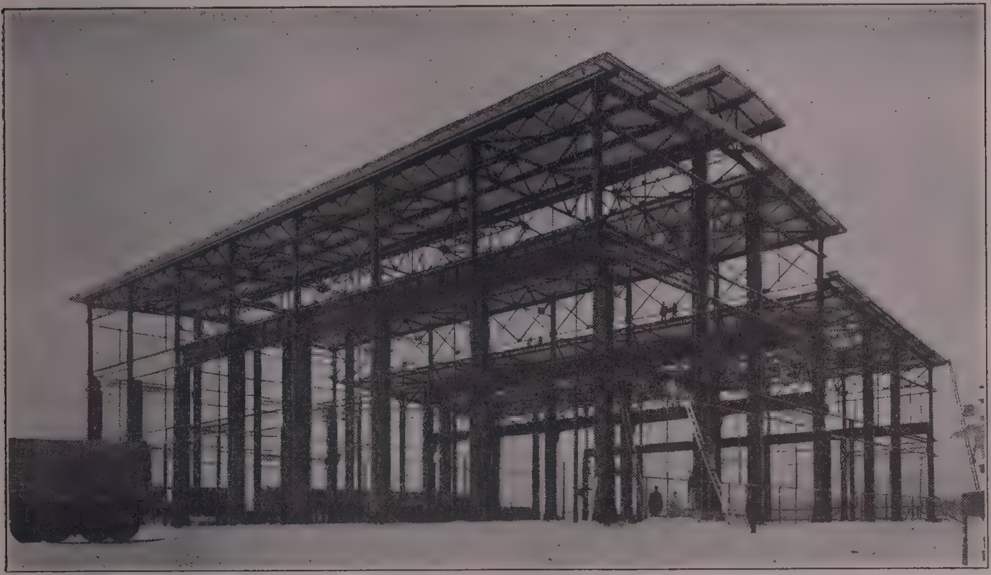
Center Column Carrying Runway Girders.

Two panels at the south end of the building have been separated from the main shops by means of a transverse partition and the space thus enclosed has been further divided by a longitudinal partition into a 44 x 100-ft. smithshop and a 44 x 45-ft. power house. The partitions have regular I-shape steel columns like those used in the end walls of the building, supporting horizontal channel girts about 10 ft. apart vertically, which are covered with expanded metal and plastered with concrete.

The foundations of the columns are proportioned for dead loads of 3 tons per square foot throughout, plus live loads of 4 tons per square foot for the wall columns and 5 tons per square foot maximum live load for the center line of columns which are subject to crane loads in both aisles. All the column piers are concrete with footings monolithic with the upper part, which has battered sides and maximum horizontal dimensions of 6 ft. 3 in. by 8 ft. for the center columns and 4 ft. 6 in. by 6 ft. for the side columns. The concrete is a 1:2½:5 mixture, with 1-in. stone.

The base plates of the columns have grouted bearings on the tops of the piers, to which each is connected by a pair of vertical anchor bolts, built 3 ft. 9 in. into the pier and provided with a U-shape bend in the middle which prevents the bolt from turning when its nut is screwed up, and a lower nut and 8 x 8-in. washer. The anchor bolts are 1½ in. in diameter for the side columns and 1¾ in. for the center columns and engage reinforced bearings of vertical angles riveted to the faces of the columns at the extremities of the long axis of the base plate. The main element of the cross-section in the column is, of course, the wide web plate and care is taken to reinforce it and distribute the column load over the base plate by means of transverse extended gusset plates riveted to the column flanges at the foot and similar intermediate plates riveted to the webs as indicated in the general column drawing and shown by the detail of the column foot and anchorage.

The transverse bents of the framework, each consisting of two roof trusses and three columns, are braced longitudinally by lattice-girder struts at the eaves and by channel-iron purlins at the panel points of the top chords, by the crane runway girders, and in the end and alternate intermediate panels of the walls by horizontal struts and X-brace rods. The corresponding panels of the roof are X-braced with single angles in the planes of the top chords, thus forming continuous towers across the full width of the building which can transmit transverse stresses to the column piers.



Machine Shop Framework Ready for 2½-In. Concrete Walls.

The roof trusses are of simple construction, with zigzag web members, which, like the chords, are pairs of angles shop-riveted together back to back on gusset connection plates. The principal connections of the trusses to the columns are made through the end top chord gusset plates, which, except in one case, form short upper sections of the column webs and are field-riveted between the column flange angles. At the deep ends of the low-level trusses, the connection is made to the center columns below the upper ends of the latter, and the gusset plate does not form part of the column web but is provided with vertical flange angles, which are field-riveted through their outstanding legs to the face of the post.

The trusses over the erecting shop are symmetrical about their center line, and except for the monitor connections, each half is identical with the outer end of the roof truss in the other aisle, thus securing a great uniformity in the shop work. All trusses were shipped in two pieces with a single field-riveted joint in the center of both top and bottom chords, and were assembled together and lifted up complete at the site and then erected by gin-poles. Each truss was hoisted by chains attached to the top chords at panel points about half way from each end to the center.

The columns in the machine shop wall carry part of the roof and one line of runway girders, and are 41 ft. long over all and about 22 ft. 9 in. high from the floor to the level of the runway girders. They have an I-shape cross-section with a solid web and two pairs of flange angles, and are like a vertical plate girder offset at the top to receive direct longitudinal loading from the runway girders and avoid eccentricity of loading. The upper part of the column carries only the roof load, which is centrally applied; this part has a 12 x ⅜-in. web plate and four 4 x 3 x 5/16-in. flange angles. Two of the flange angles are continuous the full length of the column and form part of the splice between the upper and lower parts of the web. The lower part of the column is made of a 32 x ⅜-in. web plate spliced at the upper end at the girder-seat level with two short cover plates to the 12-in. web in the upper part of the columns. The web of the lower part of the column projects 20 in. transversely beyond the inner flanges of the upper part of the column and is reinforced by those flange angles overlapping it for a length of over 2 ft., by two other pairs of similar vertical stiffener angles, and by two 27 x ⅜-in. reinforcement plates.

The runway girder is seated on the flanges of a pair of 5 x 3½-in. horizontal shelf angles, and is web-connected to the upper part of the column by transverse vertical diaphragms, shop-riveted to the columns and field-riveted to the girders. Gusset plates and horizontal connection angles are riveted across the outer flanges of the columns to provide connections for the 10-in. horizontal wall channels, field-riveted to them with their flanges down. Short angle clips are also riveted across the outer flange of the column in the lower part to provide for horizontal girt angles in the wall.

The columns in the outer wall of the erecting shop are similar to those already described, except that they are 56 ft. 6¼ in. long over all and have web plates 79 in. wide in the lower part, providing on their upper ends seats 27 in. wide which allow the runway girders to be offset clear of the inner flange of the upper part of the columns.

The columns in the center row are similar to those last described, except for the omission of connections for wall girders and for a solid-web bracket riveted to one of the flanges of the lower part to form a seat for the runway girder of the 35-ton crane in the machine-shope aisle. These are the heaviest of all the columns and were shipped complete from the shop, erected by gin poles and braced in position until they were held by connecting the roof trusses, girders and struts.

The 120-ton crane is calculated to lift locomotives from the track and transfer them from one part of the shop to another, and its runway girders are made in single panel lengths, with full-length 60 x ½-in. web plates and 6 x 6 x ⅝-in. flange angles reinforced by one 14 x ⅝-in. cover plate for the bottom flange and one 15-in. 33-lb. channel for the top flange. If the tangent distance between the fillets on this 15-in. channel is taken as the limit of the width available, the section actually used would be impracticable, for this distance is only 12⅜ in. In reality, however, the flange angles are not exactly 6 in. wide on their backs, but a little less on account of the rounding of the edges, and consequently they and the web fit in between the flanges of the channel, although some designers disputed the practicability of such detailing. The girders are divided into panels from 2 to 5 ft. long by pairs of 5 x 3½-in. vertical web-stiffener angles and fillers, and in the end panels the webs are also reinforced by four ⅝-in. plates. The girders are made ¾ in. short of the panel lengths and their abutting ends are field-riveted together through the outstanding flanges of the vertical web-stiffener angles and to the transverse diaphragm plates previously mentioned, which are shop-riveted to the flanges of the columns and thus give the girders lateral stability in addition to that secured by the channels in the top flange. The girders for the 35-ton crane runway are of similar construction except that the web is only 36 in. deep.

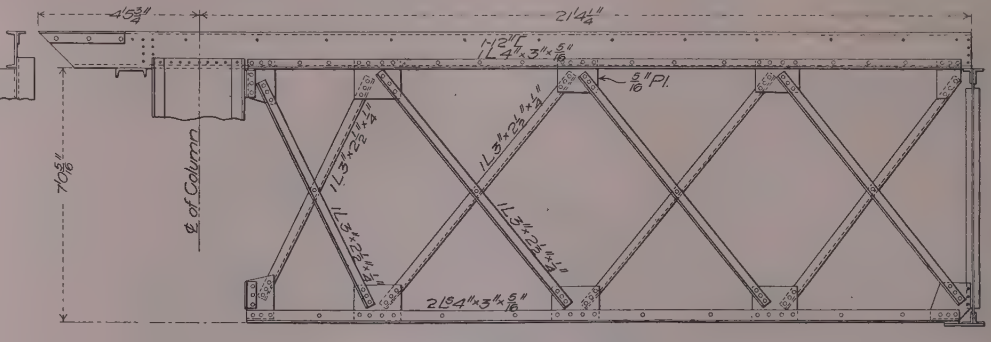
The ends of the building are each divided into five vertical panels by the intermediate I-shape wall columns, and the two outside panels and that nearest the center column are divided into three horizontal panels by two I-shape transverse struts made of two pairs of 5 x 3-in. angles back to back, latticed, with vertical connection plates riveted between them at the ends and provided with vertical flange angles in the faces of the columns. Pin holes through the angles and connection plates at both ends of the struts receive the diagonal X-brace rods.

The intermediate purlins in the end panels are lattice girders of the full depth of the roof trusses, which support them at one end where their top flanges are seated on the top flanges of the roof trusses, and the bottom flanges are field-riveted through vertical gusset plates to the bottom chord connection plates of the trusses. The purlins have bottom flanges made of pairs of angles back to back and are connected to the top flanges by X-brace web members of single angles. The top flange has a 12-in. channel and one 4 x 3-in. full-length angle, the outer end of the channel projecting nearly 6 ft. beyond the end of the angle to engage a horizontal seat on top of the wall column and to cantilever beyond it to carry the cornices and the upper wall girder. The intermediate purlins are similar to these, except that they do not have the projecting top-flange channels.

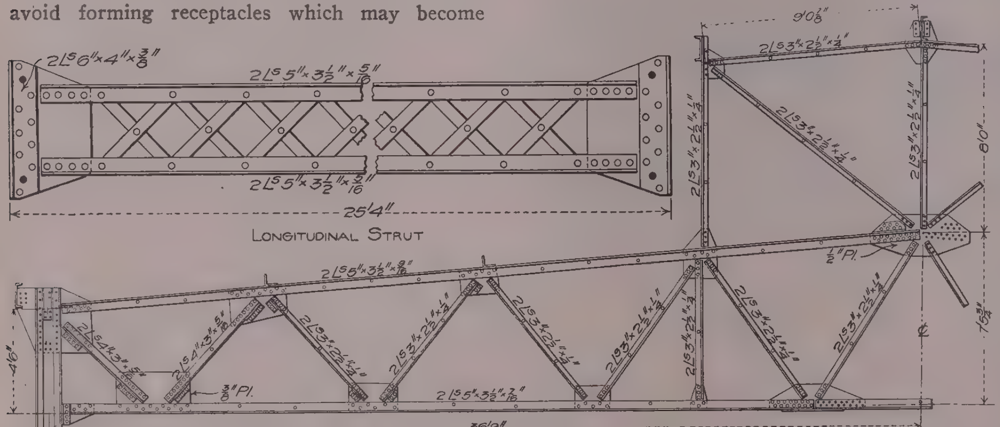
All outer walls have 2½ in. of cement mortar plastered on metal framework. The horizontal wall channels already mentioned give transverse stiffness to the wall, resist wind pressure and are spaced and connected by ¾-in. vertical channels, about 12 in. apart on centers, to which is secured expanded metal lath. On each side of the expanded metal there is one coat of mortar made one part of Portland cement and three parts of sand, mixed with hair or other fibre and having a slight addition of lime. The second coat of 2:1 mortar is put on the inside only and the third and fourth coats, on both sides, are made with 1:1½ mortar, each applied as quickly as the preceding coat has set sufficiently to support them. The thickness of the lower part of the wall is increased to about 6 in. to form a water table about 2 ft. above floor level. This bottom part of the wall extends about 9 in. below ground, to make the building tight. The entire weight of the walls is carried by the structural metal work, the walls themselves acting as beams between columns.

Nailing strips are bolted to the top flanges of the purlins and receive the 2 x 6-in. tongue-and-groove roof planks, two panels long, which break joints on purlins and have staggered joints. Although they have a clear span of about 9 ft. between purlins they prove stiff and rigid and permit workmen to run and jump on them. The planks are covered with asbestos roofing applied by the Franklin Mfg. Co., Franklin, Pa., and guaranteed for ten years. All window sash are made of 1¾-in. white pine and are pivoted. The 12 x 17-ft. doors in the end and partition walls are 1½-in. pine sheathed with 1⅛-in. diagonal boards, and on one long wall of the building there is in each panel one large Kinnear steel rolling door. There are two 12-in. ventilators in each hipped skylight and fourteen 24-in. ventilators in the monitor roof, all of them furnished by David Lupton's Sons Co.

The 10-in. horizontal wall channels form the door lintels, window lintels and sills and have wooden filler strips countersunk-bolted to their webs to receive the frame pieces, which are securely nailed to them. All of the wall channels are placed with their flanges down so as to avoid forming receptacles which may become filled with rubbish and moisture, and the vertical jambs of the windows and doors are bolted to light stud angles in the steel framework of the wall. The roof gutters are formed by fascia boards with ornamental mouldings secured to the edges of the roof planks and provided with inside fillets and flashing pitched to deliver the water to eight lines of vertical conductor pipes 5 in. in diameter on the machine shop side, and eight 4-in. pipes on the erecting shop side.



End Purlin, Lehigh & Hudson River Railway Shops.



Longitudinal Strut

Half of Roof Truss.

The clere-story windows in each side of the monitor are simultaneously operated very quickly and easily from the floor level by geared shafts with bronze bushings and hardened steel bearings running in oil. This device is found very convenient for opening or closing the 150-ft. lines of windows, which are not easily accessible for direct operation.

The light color of the interior woodwork helps diffuse and reflect the light. Economy and convenience were effected by painting the under sides of the roof boards before they were nailed to the purlins.

There are in the machine shop and temporary smith shop and power house, seven locomotive stalls each provided with a 4 x 70-ft. pit, 3 ft. deep, of the Erie standard type.

The machine shop is warmed by hot blast delivered by a 92-in. fan of the Buffalo Forge Co. make, operated by a single vertical center crank direct-connected engine. Hot air is delivered about 8 ft. above the floor level through two outlets, one in the center and one near the partition wall of the machine shop, and through one outlet in the smith shop and one in the power room, and is guaranteed to maintain a temperature of 70 degrees F in weather 10 degrees below zero.

The buildings contain about 390 tons of structural steel and, except the 2½-in. outer walls which were purposely delayed to avoid concreting in frosty weather, were erected complete and ready for the installation of their equipment in about four months after the excavation for the foundation pits was commenced. All foundation work was done by the railway company's employees. The design and construction was under the direction of Mr. Morris Rutherfurd, vice-president and general manager of the Lehigh & Hudson River Ry., and in immediate charge of Mr. S. E. Barrett, superintendent of tracks, bridges and buildings, the designs and specifications being made by Mr. Mason R. Strong, consulting engineer. The American Bridge Co. was the contractor for the structural steel work; and Welch Bros., Warwick, N. Y., for the remainder of the work.

Razing a 125-ft. Brick Chimney, under conditions that required accurate work to avoid damaging neighboring buildings or obstructing nearby railway tracks, was successfully accomplished recently in Philadelphia at the former site of Crow's Caledonia Worsted Mills. Bricks were removed from the base of the chimney on three sides and timber blocking was substituted. The brickwork on the side opposite the desired direction of fall was left intact. The blocking was then saturated with oil and set on fire. As the fire progressed the chimney gradually began to careen till it was about 15 deg. from the vertical when it broke about 20 ft. above the ground.

Some Practical Aspects of Steam Railroad Electrification.

"The railroad man with a particular problem to solve is almost as much in the dark as ever as to the practical value of the new motive power for his particular conditions." This summary of the usefulness to railroad officials of the papers on electrification printed to date occurs early in a paper on practical aspects of steam railroad electrification presented on Dec. 6 before the Ithaca section of the American Institute of Electrical Engineers, by Mr. W. N. Smith, the electrical traction engineer of Westinghouse, Church, Kerr & Co. It is his opinion that this very complicated subject must be approached by degrees, on the basis of examples involving different physical and traffic conditions, because general curve sheets, valuable in theoretical electrical investigations, are apt to be meaningless to the steam railroad official. Furthermore, he believes that in discussing a problem of such tremendous proportions, the matter of the particular electric system to be employed should not necessarily be placed foremost, but practical railroad operating conditions must be regarded as of main importance. His paper was written for the purpose of stating the problem in its general scope rather than as a contribution to the exclusively electrical parts, and its leading portions are given in the following abstract:

The electric railway industry occupies a peculiar position as compared with the general trade in railway appliances. A practical monopoly of electric propulsion apparatus is divided among a very few large companies. This is somewhat similar to the general situation as regards steel rails and steam locomotives, both of which commodities are produced by a relatively small number of manufacturers. With electrical motive power apparatus, however, the art is relatively much newer, and the number of trained specialists is fewer, and mostly concentrated at the manufacturers' shops so that the opportunity afforded the manufacturers to inspire and direct the formation of their customers' ideas on electric propulsion has not been neglected.

By the time that twenty or thirty roads have electrified their lines, wholly or in part, the attitude of their operating and maintenance engineering forces may become an important factor in the situation; and the commercial rivalry now shown in devising and perpetuating electric systems will then be diverted from its present tendencies, toward the more natural function of competing to furnish apparatus as specified by the railroads.

The consulting engineer's standpoint at the present time is that of an interpreter between the manufacturer and the railroad. He is frequently charged with a very grave responsibility in aiding the railroads to decide some very fundamental and perplexing question arising from the relationship between the old art and the new. Although he may write new and complete specifications for all the parts of manufactured apparatus involved, he is generally not called upon to design it in detail, as that function is still practically monopolized by the manufacturing companies, though subject in some degree to the consulting engineer's control. He has not only to act as mediator between the railroads and the manufacturing companies, but he must also secure co-operation between the various departments of the railroad itself which are intimately concerned with the work he is doing; that is to say, the construction, maintenance, mechanical and transportation departments—all of which, in many instances, have to be consulted with reference to a single detail. The pioneer engineering work of steam railroad electrification, up to the present time, has largely been done on the initiative and with the aid of consulting engineers, whose usefulness to the railroad in the above described capacities has been very notably demonstrated.

A project for the electrification of a railroad is usually attractive, because of the increased amount of traffic it becomes possible to handle in proportion to the expense of handling it. This is usually directly accomplished by increasing the speed of revenue train-movement over a given piece of track, and by reducing the amount of non-revenue train-movement. Such questions are, of course, most pressing where conditions of traffic congestion are most severe; and for that reason most of the heavy railroad electrification has hitherto been worked out in and near New York City, where the maximum movement of passenger trains is required in the minimum amount of area available for terminal facilities. In much of the work referred to, the prospect of immediate returns upon the investment had to be considered as of secondary importance. But in proportion to the total mileage of the country which may ultimately prove fit for electrification, territory of such a character is relatively small in extent.

The more general cases, however, are not likely to be regarded by the financier in quite the same light, although it is believed that they can be more convincingly solved on their financial merits alone than is possible in the case of expensive metropolitan terminals. When the railroad man is looking at a transportation problem from the constructive and maintenance standpoint, he has in mind the crystallized experience of some 70 years of steam railroad practice that has resulted in the development of railroad equipment along certain lines, which, generally speaking, are rather conservatively maintained. A departure from some previously recognized form is often found good, but there is nevertheless considerable resistance to change. In justice to steam railroad men, however, perhaps it should be said that opposition to new forms is not likely to be so great because of radical difference in themselves, as because of the great cost of keeping on hand a line of repair parts entirely different from those which their present historic equipment obliges them to carry in stock. Although the electrical equipment will necessitate, for its own maintenance, the addition of a considerable quantity of repair stock, it should not without good reason be permitted to change any previously existing standard that it is desirable to keep.

On the other hand, there may be some very fundamental reasons for changing existing standards in order better to accommodate certain electrical features. An instance of this upon a certain railroad was the adoption of a new shape of splice-bar, specially rolled, to accommodate a heavy rail-bond underneath it, upon a section where some new track was to be laid; while the objection of another railroad to increasing the diameter of a motor-car wheel on account of the additional size of tire that would have to be carried in stock, eventually resulted in the retention of an electric motor originally adopted for a lighter car. At first the motor had been thought too small for the increased duty which was to be imposed upon it, but was found to be adequate when fitted with suitable means for increasing its capacity, thus satisfying the desire of the railroad for the maintaining of standards in its equipment and at lower cost.

The question of clearances has often been most perplexing, particularly as regards the location of either third-rail or overhead trolley construction. The stationary features pertaining to the right of way, and the dimensions of moving equipment, must not be allowed to interfere with each other. The third-rail sometimes conflicts with bridge-gussets on the one hand, or with hopper-bottom coal-cars on the other. The use of the third-rail also makes more necessary the elimination of highway grade-crossings, and requires careful attention to the protection of the public at station platforms. Low overhead bridges conflict seriously with trolley construction, particularly when high voltage is desired.

High-tension trolley construction introduces, among other problems, the purely mechanical one of providing suitable warning signs or ticklers for trainmen on the tops of freight cars; these must not only be light enough not to injure brakemen, nor damage the trolley mechanism on moving equipment, but must also be heavy enough to withstand the blows they receive from the trolley without being broken or rendered useless.

Either type of construction may require special and often expensive arrangements at drawbridges. The civil authorities in cities sometimes arbitrarily insist upon placing high-tension lines underground, which is always expensive. Telegraph and telephone lines have to be protected from mechanical and electrical interference. These are a few of the characteristic problems that arise with each electrification scheme, but solutions of them do not appear on the mathematical curve sheets with which professional papers are sometimes illustrated.

Looking again at cars and locomotives, the steam railroad man will commonly take his standard coach as the point of departure, and suggest at the outset that it be equipped electrically practically as it stands. Here it is entirely in order to remark that the main object of electrification is to facilitate traffic. The car bodies themselves should be built with that end in view, in order to get the full benefit of the superior type of power. The object to be attained affects the dimensions of the vestibules, doors, and seats, as well as the length of the car, and even the form of roof of the car may be altered from standard types without detriment to passengers, if external conditions make it desirable. Suburban service is the type of service that admits of the greatest modifications in this respect; and that car is likely to be the most popular with the patrons of the road which is so built as to enable freer ingress and egress of passengers, a matter which should not be lost sight of where there is competition between different lines to be taken into account. It is no little tax upon the engineer's ingenuity to get the best results in a new development, and still conform to the general lines of conventional car designs, some features of which have been based upon rules and practices primarily imposed for the greater safety of the traveling public.

Coming now to locomotive design, perhaps the most fundamental advantage which an electric locomotive has over its steam predecessor is greater mechanical simplicity, particularly as regards translation of the tractive effort from the motor to the wheel-rim. The absence of reciprocating parts is advantageous to a high-speed electric locomotive for passenger service, because of the lessened vibration of the locomotive itself, and the greater diminished wear and tear on the track. In the case of a slow-speed electric freight locomotive, the uniformity of tractive effort in hauling heavy train loads is a very desirable feature, particularly at starting. The tendency towards simplification and elimination of reciprocating parts has caused the concentration of great weight at a less height above the rail than is usual for a steam locomotive of equivalent power; and this lowering of the center of gravity is not without its effect in running conditions at high speed, particularly upon a curved track. Steam locomotive men regard a high center of gravity as advantageous rather than detrimental, because its longer leverage from the top of the rail, which is the fulcrum, eases the side-thrust against the rails, due to whatever centrifugal force or lateral vibration there may be. If electric locomotive designers in this country keep as clear of the use of side-rods in the future as they have in the past, there does not seem to be much chance for increasing the distance of the center of gravity from the track to the height it frequently reaches with a steam locomotive; but in Europe some of the latest and most successful electric locomotive designs show a tendency to set the motors above the driving wheels, two motors being used to drive three axles through side-rods.

Railroad electrification invariably raises questions of safety to the traveling public. Both the third-rail and the trolley are frequently described in the daily press as "deadly." In fact that on a third-rail system a bad short-circuit can take place without blowing the station circuit-breakers, which have to be set for heavy overloads, sometimes results in serious blockades. When the damage is done it is usually expensive, and takes time to repair. In the case of a high-tension trolley system only a small leak is sufficient to cause a short-circuit, and the amount of actual damage done thereby is trifling. Such troubles as may be developed by short-circuits are generally not of long duration; whatever wires or cables are burned in two are burned quickly, and clear themselves promptly. With a high-tension system there is no possibility of confusion between an overload and a short-circuit.

Another feature of the question of safety involved is the dependence of a large number of electrical transportation units upon one power station as opposed, in the case of steam transportation, to an equivalent number of entirely independent units. It is perfectly possible for a disabled electric train to ground or short-circuit the line in its own vicinity in a manner that will prevent other trains from approaching. This is not the case with steam locomotive trains, as the terrible record of steam train collisions bears witness. Generally speaking, the combination of electric propulsion with the block-signal system for protecting trains has not been developed, though in the early days of the art the matter was occasionally brought forward as additional argument in behalf of electrification. The paramount desire to keep all traffic in motion has militated against the idea of permitting the disabled train or line-section to hamper in any way the movement of other trains on other sections. It is evident that there are possibilities along this line, particularly in the case of high-tension systems, that can justly receive further consideration, because with the smaller currents flowing in high-tension systems, control of them at a distance is relatively easier than in the case of the heavier currents in low-tension systems.

The phase of the question which, in Mr. Smith's opinion is probably the most complicated and least understood of all, is the standpoint of the railroad operator or transportation superintendent, and his organization, upon whom the railroad depends for maintaining its earning power. It is conceded by all, that the great thing to be desired in a railroad of given proportion is capacity for train-movement. The capacity of a double-track road is stated to be in general about four times that of a single-track road, general conditions as to grade and location being equal; but as more than 70 per cent. of the railroad mileage of the country is single track, the most universal problem of increasing track capacity by electrification will apply to single-track rather than to double-track lines. This, of course, excepts terminal and suburban conditions, but includes the majority of mountain railroad conditions, where double-tracking is sometimes a physical impossibility.

On the greater proportion of single-track railroad mileage, trains are handled by the telegraphic train-order system under the control of train dispatchers. On some railroads, however, block-signal systems are installed to facilitate the movement of trains, as much time is thereby saved by each train in getting the right to pass from one block to the next. According to a report by the Interstate Commerce Commission, published about March 1, 1907, the total number of miles of railroad lines which had any block-signal system at all was 143,615, of which 48,743 miles was actually equipped and operated by some form of block-signal system. Of this 48,743 miles, 6,826 were operated by the automatic system and 41,916 by one of the several forms of non-automatic system. Of the mileage controlled by the automatic system, 2,032, or somewhat under one-third, was single track. Of the lines controlled by non-automatic signals, 33,585 miles were single-track lines, making a total of 35,617 miles of single-track railroad in the United States controlled by some form of block signal. The total mileage of single-track lines in the United States is estimated at about 200,000, so that about 17.5 per cent. of the total single-track mileage is controlled by block signals at the present time. Inasmuch as the operation and maintenance of a block-signal system is undoubtedly cheaper per mile of road than the total annual cost that would be incurred by electrifying, it would appear that the first step in increasing the capacity of a road is to establish a suitable block-signal system. Thus from a practical standpoint the mileage of track where electrification could profitably be considered under present conditions would be greatly reduced; but when the increased capacity created in any instance by a block system has been fully utilized, a further increase is still possible by the use of electric motive power.

Engineers familiar with the interurban trolley development of the past ten years are aware that most lines of this type dispatch their trains very largely by the telephone system. Generally speaking this method works very well, though on the more highly developed systems it is combined with some of the features that have been standardized by the rules of the American Railway Association, and adopted by practically all the steam railroads. It must be remembered, however, that conditions on trolley roads are somewhat different from those on steam roads. The vast majority of the trains are light passenger trains of one car each, stops are of shorter duration, and the speed of all trains is more nearly uniform. The distance between turnouts is less. The penalty of a wreck due to misunderstanding or miscarriage of orders is, generally speaking, much less with the average interurban trolley road than with the average steam railroad; and trolley railroad operators are correspondingly more willing to run the risks incidental to dispensing with the system of transmission of train orders, which experience has shown to be necessary on steam railroads. The meeting points are generally much nearer together, and a block system of any kind would cost relatively more to maintain and operate in proportion to the business done than is the case with steam railroads.

Whether the telegraphic train-order system or one of the other systems of block signals be used, the rules governing the operation of trains on steam railroads are very rigid. The telegraphic train orders, emanating from the train dispatchers' office, must be signed by the recipient and the signature telegraphed back to the dispatcher, who then replies "complete" to the various operators to whom he has sent the message as fast as their replies come in. An order restricting the rights of a superior train is more rigidly safeguarded in this respect than an order increasing the rights of an inferior train; and a superior train must receive and reply to its orders before any can be given to the inferior train. Much time may be and often is thus consumed, which may restrict considerably the capacity of a line to handle traffic.

Another rigid type of rule is that requiring an inferior train to clear the time of a superior train at a meeting or passing point by not less than five minutes. This holds whether a train-order system or a block-signal system is used. This five minutes' clearance is frequently, for special reasons, increased to ten minutes and often to twenty minutes, thus placing the inferior trains at a still greater disadvantage. The fastest high-speed "flyers" of the present day are thus protected, to the greater safety of the passengers, but to the disadvantage of freight trains. Two such flyers, one in each direction over a road per day, will thus cut down the current of slower traffic over the whole road to the extent of at least 40 minutes per day, and frequently more. If an inferior train cannot make an intended siding in time to allow for the required clearance it is obliged to wait on a nearer siding and lose the time required for the superior train to cover the distance between the two sidings, plus any extra time which the superior train may have been delayed. If traffic is dense, and sidings far apart, such delays become very serious, and besides the delay to freight, and disappointment and inconvenience to shippers and per diem charges on cars, there is added the overtime due to the employes, which increases the operating expenses.

A case was recently cited of a single-track road in a mountainous country where double tracking would be a very expensive proposition, this road having a heavy traffic in both directions, loaded ore cars coming down and empties going up. It was found in operation that the easiest way to get the traffic over the road was to make every siding a meeting point, that is to say, the road was practically full of trains. The only way of increasing traffic on such a line other than by double-tracking would be to increase the speed of all trains in the same proportion. This might seem feasible enough by electric motive power, but then arises the question whether the increase in speed that could be thus obtained would be sufficient to enable an increase in the daily traffic that would pay a dividend on the total cost of electrification. This would be an excellent instance of a concrete case in which other things than motive power costs alone, of steam and electricity, would have to be considered. In a case of this kind, the capacity of a single-track road would be limited by the speed of the slowest train.

The task of working out the results in such a case is necessarily complicated and would require nothing less than a close study of all the conditions on the ground. The fact that it is impossible to generalize upon the capacity of single-track roads for train movement, renders it equally impossible to generalize upon the applicability of electric motive power thereto in comparison with steam. It is necessary to pick out a concrete case and estimate all the features in detail, just as it is in order to properly gauge the economic value of any other engineering enterprise. It is obviously unscientific to advocate wholesale electrification as a means of increasing capacity, when the capacity can be increased more cheaply, as it sometimes can, by the introduction of a block-signal system, or when the capacity of a piece of road even when equipped with a block-signal system, could not be increased in practical operation to a point that would enable enough more ton-miles per day to be run off at a lower cost per ton-mile, to show a saving in total annual cost.

The writer is a firm believer in the value of electric motive power as a means of increasing a railroad's earning capacity, but begs to suggest that in the future more professional papers be devoted toward giving concrete illustrations in a manner that will carry some conviction to the minds of the progressive and highly trained specialists in transportation, who are doubtless willing to be convinced if the subject can be dealt with in a manner that appeals to their practical experience in the operation of trains.

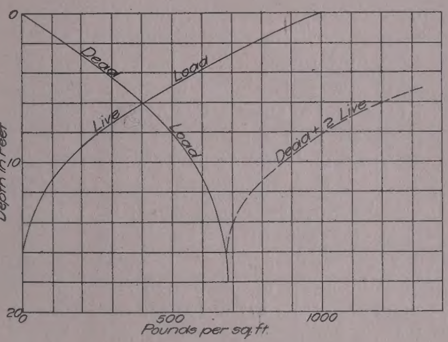
Book Notes.

In a profusely illustrated book of 248 pages, entitled "Reinforced Concrete in Factory Construction," Mr. Sanford E. Thompson gives a comprehensive description of a number of important industrial buildings of different types and a considerable amount of general information on this material, the whole presented in such a way as to furnish data useful alike to the factory owner, designer and builder. The first chapter is an explanation of the utility of reinforced concrete for such structures, and takes up cost, safety, durability, fire resistance and insurance, stiffness, rapidity of construction, cleanliness and other points. The second chapter is on the design and construction of reinforced concrete buildings, taking up the materials, forms, foundations, floors, beams, columns and roofs. The third chapter is on concrete aggregates, their selection and use. The fourth chapter is a description of the Pacific Coast Borax Refinery at Bayonne, N. J., designed and built by Mr. Ernest L. Ransome ten years ago, the first reinforced concrete factory in the Atlantic States, and noteworthy also for having been subjected to a severe fire. Chapter 5 describes the eight-story 80x67-ft. Ketterlinus Building in Philadelphia, which is filled with printing machinery and, although it cost only about 13 cents a cubic foot, including the inside finish, is giving better satisfaction than the adjoining steel frame building owned by the same people. This building was designed by Ballinger & Perrot and was built by day labor under their direction, and contains a number of unusual structural features. Chapter 6 describes the Lyn Storage Warehouse, designed by the Eastern Expanded Metal Co., with Mr. J. R. Worcester as consulting engineer. The floor specifications of this structure are unusual. Chapter 7 describes the 256x107-ft. shop of the Bullock Electric Co., at Norwood, which has the runways for 10-ton cranes carried on concrete brackets which form part of the columns; it was designed and built by the Ferro Concrete Construction Co., of Cincinnati. Chapter 8 describes a four-story 500x132-ft. storage building of the Wholesale Merchants' Warehouse Co., of Nashville, Tenn., built by the Oliver Co. from the plans of McDonald & Dodd, a cableway being used in handling the materials. Chapter 9 describes the first model factory of the Bush Terminal Co., in Brooklyn, built by the Turner Construction Co. from the plans of E. P. Goodrich. Chapter 10 describes the Packard Motor Car Co.'s shops in Detroit, designed by Mr. Albert Kahn and built by the Concrete Steel & Tile Construction Co.; the columns in this structure are about 32 ft. apart. Chapter 11 describes the four-story 50x200-ft. factory of the Textile Machinery Works, of Reading, Pa., designed by the Concrete-Steel Engineering Co., of New York; the bays of this building are 24x12½ ft., and the beams and girders are of the open Visintini type, cast under a shelter and put in place like steel girders on brackets on the concrete columns. Chapter 12 describes the cold storage warehouse at Richmond, Va., built for Mr. W. S. Forbes from the plans of Wilder & Davis. It is four and six stories high and about 83x160 ft., and its reinforced concrete features were designed by the General Fireproofing Co., which used pin-connected girder frames for the reinforcement of the beams and girders. Chapter 13 describes the construction of several shops at the Northampton mills of the Atlas Portland Cement Co., which are noteworthy for having the wall piers or pilasters run up first as independent columns, 14 ft. apart on centers, and the walls then cast between them. In all these chapters, the details of design, forms and cost receive special attention. Chapter 14 describes the various types of reinforcement steel on the market, the different patented systems of construction which are in general use, concrete piles and surface finish. In an appendix there are many pictures of reinforced concrete factories not described in the text. (New York, Atlas Portland Cement Co.; cloth, 50 cents; paper, free.)

Probably no engineering handbook, except that of the famous Verein Hütte, was ever written under such favorable conditions as the "Standard Handbook for Electrical Engineers." The need for it became evident long ago from the incessant stream of questions flowing toward the manager of the book department of the McGraw Publishing Co. and the editors of the "Electrical World" and "Street Railway Journal." Most of these questions could be answered by reference to books, but when a man asked a good many questions he was referred to so many books that he probably felt inclined to look upon the answers as an attempt to sell him a little library. So Mr. Caldwell, the manager mentioned, determined to bring together in a single handbook a pretty complete survey of the field of practical electrical engineering, written by people who are familiar with the branches of the subject and know from experience gained in their regular duties what kind of information is most sought. It was determined at the outset to avoid any duplication of the material in the handbooks of Trautwine and Kent, outside of mathematical formulas and tables, and to confine the book strictly to electrical engineering, save in the chapter devoted to central stations, where it was apparently essential to give a synopsis of present methods of developing hydraulic power and designing the steam plant for driving alternators. In this chapter on central stations the topics are taken up in a somewhat different manner from that followed in any other book, since this is an electrical and not a civil or mechanical volume. The scope of the contents is best indicated by giving the chapter headings: 1, Units; 2, Electric and Magnetic Circuits; 3, Measurements and Measuring Apparatus; 4, Properties of Materials; 5, Magnets; 6, Transformers; 7, Electric Generators; 8, Electric Motors; 9, Batteries; 10, Central Stations; 11, Transmission and Distribution; 12, Illumination; 13, Electric Traction; 14, Electrochemistry; 15, Telephony; 16, Telegraphy; 17, Miscellaneous Applications of Electricity; 18, Wiring; 19, Standardization Rules; 20, Tables and Statistics. It is manifest that a book of 1,300 pages of fine print covering these subjects is an important accession to the library of any engineer whose work is outside a very limited range of special subjects, as the enormous volume of orders received as soon as the volume was announced has fully demonstrated. Certain chapters are particularly valuable to civil engineers. That on electric traction, written by Mr. A. H. Armstrong, is, in some respects, the best source of information concerning electrification of steam roads that is now in print. The author's grasp of the subject is personally known to the chief engineers of a good many important railways, and they in particular will understand what a service he has rendered when they see in print his valuable charts and data of which they have hitherto had only a general knowledge. The chapter on illumination, by Dr. Louis Bell, will be a boon equally to the architect and the municipal engineer, as it brings together in compact form the principles upon which lighting arrangements must be based to give the best results. The chapter on electrochemistry, by Dr. E. F. Roeber, will be found an interesting and authoritative survey of a branch of engineering which a number of shrewd specialists consider destined to make enormous improvements in various industrial processes in a comparatively few years. These comments might be extended to several other chapters, but enough has been said to indicate that the book will prove a most valuable reference manual to anyone interested in the subjects it covers. (New York, McGraw Publishing Co., $5.00.)

A brochure on the proportioning of concrete which is attracting considerable attention in Germany bears the title "Materialbedarf und Dichtigkeit von Betonmischungen." The author, Mr. H. Nitzsche, states that the customary methods of determining proportions does not always give the most economical mixture, owing to a failure to pay enough attention to the density of the concrete, as when it is desired to obtain material of high strength, but not of great diversity, or a concrete that is very dense but not particularly strong. He develops formulas taking account, 1, of the proportions of the ingredients; 2, the shrinkage in volume of the mortar (Môrtelausbeute); 3, the voids in the loose sand and stone; 4, the excess of mortar to insure filling the voids; 5, the density of the concrete; 6, the compressibility (Zusammenstampfbarkeit) of the sand and stone. These formulas are made more readily useful in two charts, and a number of examples are solved showing the range of problems which the diagrams cover. The author denies any probability of predicting the strength of concrete by these methods, but gives them publicity as a means of effecting a saving in cost of concrete. (Leipzig, Wilhelm Engelmann, 1.60 marks.)

AN AFRICAN RAILWAY of some interest is now under construction westward across the desert from Farshut, a town on the Nile about 300 miles from Cairo. The line is known as the Western Oases Ry., and in its construction a large number of camels were used, a fact on which considerable emphasis is laid by the "Engineering Magazine." This use of camels was the natural thing in the Libyan desert, but a real novelty in the way of strange uses of animals has been seen at Long Beach, a few miles from New York, until cold weather began. A great deal of construction is in progress there, and three elephants were employed for a time in handling heavy materials, probably the only case where such animals have been regularly used on construction work for any length of time in an American city, with the possible exception of Bridgeport, where a famous circus has large permanent headquarters and the elephants are used to some extent.



Loads on Sewers.

Letters to the Editor.

BREAKING OF LARGE STEEL BEAMS.

SIR: The breaking of 20-in. beams described by Mr. Samuel M. Green in your issue of Dec. 28 is not so uncommon as might be desired. In one instance, an 18-in. beam split along the center of the web, beginning at one end, and with such force as to seriously injure a workman sitting on it. This case eventually came into the courts of Illinois through suits brought in the interest of the injured man.

About ten years ago the writer used 20-in. beams as girders in a manufacturing building at Schenectady, N. Y. While unloading these beams from a flat car, one broke in precisely the manner mentioned by Mr. Green, except that the break extended quite through the beam. Neither chemical nor physical examination developed any reason for the break and the balance of the beams were used in the work.

It is, perhaps true, that these difficulties were more frequent when most of the steel used was made by the Bessemer process than they are at present, but even now they are frequent enough to give considerable basis for the reluctance many engineers have for using beams larger than 15-inch. Very truly yours,

Albany, Dec. 31. WALTER R. MARDEN.

LOADS ON SEWERS.

SIR: The magnitude of the loads to be considered in the design of sewers has engaged considerable thought of those devoted to this work, but very little information concerning it has found its way into current technical literature. It is, therefore, in a spirit of thankfulness that we meet this subject discussed in the "Beton Kalender" for 1908. On page 363 of the second volume the dead and live loads for various depths are given in the metric system. The quantities are obtained on the assumptions that the weight of earth coming on a structure increases with the depth, according to the law of a parabolic curve, with its vertex 16.4 ft. below the surface and the axis horizontal; and that the live load decreases with the depth according to a similar law, the effect of the live load being nil for all depths below 16.4 ft.

The following equations embody the relations of the dead and live loads in pounds per square foot with the depth, d, in feet:

$$\text{Dead load} = 83.d - 2.54d^2$$

$$\text{Live load} = 1{,}000 + 3.72d^2 - 122d$$

For the total dead and live load the author of the article combines two-thirds of the dead load with the live load. To bring the results in conformity with American practice it would be better to combine the dead load with twice the live load to obtain the total load which the structure should be designed to sustain. This will allow for the dynamic effect of the live load.

A table and diagram have been prepared based on the formulas for the dead and live loads. The average weight of cover is taken at about 120 lb. per cubic foot. The results given agree only approximately with their metric equivalents:

LOADS PER SQUARE FEET FOR DIFFERENT DEPTHS.

Depth.	Dead load.	Live load.	Dead load + 2 × live load.
5 feet	350 lb.	480 lb.	1,310 lb.
6 "	410	400	1,210
7 "	460	330	1,120
8 "	500	260	1,020
9 "	540	200	940
10 "	580	150	880
11 "	600	110	820
12 "	630	70	770
13 "	650	40	730
14 "	660	20	700
15 "	670	10	690
16 "	680	0	680
16.4 "	680	0	680

It will be observed that the total load decreases with the depth of cover. In this respect these formulas differ radically from those which have the total load increase with the depth.

New York, Dec. 30. SAMUEL D. BLEICH.

A REMARKABLE CEMENT KILN RECORD.

SIR: The following output records for cement kilns are the largest that the writer has met with in his experience or has had his attention directed to and believes that the same are worthy of mention:

One 8x125-ft. kiln:
Nov. 29; day shift, 546 bbls.
Nov. 29; night shift, 410 bbls.
Nov. 30; day shift, 507 bbls.
Total for 36 hours, 1463 bbls.
Two 8x125-ft. kilns:
Dec. 13; day shift, 747.5 bbls.
Dec. 13, night shirt, 754 bbls.
Total for 24 hours, 1501.5 bbls.

The clinkers were caught in 1½-yd. steel side-dump narrow-gauge cars and taken to track weigh-scales placed in such a way that it was impossible to get to the clinker bins without running the cars over them. Each car was carefully trimmed at this point to weigh 2,444 lbs. net clinker, or 6½ bbls.

The kilns are 125x8 ft. in diameter, burning fuel oil at a temperature of about 90° Fahr., under a pressure of 95 lb. per square inch. The speed of the kilns was about one revolution in one and one-half minutes. The air used in atomizing the oil at the burners was supplied by a positive blower at a pressure 30 to 36 oz., varying with the amount of air used by the burners. Each kiln was supplied with three burners, although but one was used.

The average fuel consumption for the period of Nov. 29-30, was 10.7 gal. per barrel, and for the period of Dec. 13 was 9.3 gal. per barrel. The draft for the kilns was a direct draft through the kiln and out of the stack, for no economizer device was in this case installed to utilize the available heat units which escaped in the waste gases.

The material used was the geological equivilent of Iola limestone and shale.

Nov. 29, day shift, average fineness, 95.1%.
Nov. 29, night shift, average fineness, 90.6%.
Nov. 30, day shift, average fineness, 94.3%.

The volumetric analysis for the above period averaged 75.5 per cent. calcium carbonate and the clinker produced was found to contain 62.5 per cent. lime.

The pats boiled for five hours for both day shifts were sound, although the night samples showed slight signs of disintegration.

Dec. 13, day shift, average fineness, 95.3%.
Dec. 13, night shift, average fineness, 95.6%.

Raw material, volumetric analysis, 75.5 per cent. calcium carbonate.

Lime in the clinkers, 62.75 per cent; five-hour boiling test, sound.

Fineness was obtained by dry sifting, no brushing or forcing.

Although these records were obtained at isolated periods, the general average has been remarkable for kilns of any size. The plant is a four-kiln plant designed and constructed by the Freeborn Engineering and Construction Co. for the Kansas City Portland Cement Co., with a well-balanced capacity of 2,400 bbl. daily, and when the quarry has been well opened so as to furnish an adequate supply of raw material, it is possible that even these high records may be surpassed.

Considerable credit is due to the night superintendent, Mr. W. C. Shaffer, and the master mechanic, Mr. Wm. Boerma, for the intelligent manner with which they handled the plant, and also to Mr. C. H. Sonntag, chemist, for accurately controlling the mix, making so high an output of sound cement possible. The last of these records was made under the direct supervision of the writer during a capacity test made in the interests of the engineers for the plant.

E. H. RICHMOND.

Grand Rapids, Dec. 16.

TESTS OF BOND BETWEEN PLAIN BARS AND CONCRETE.

SIR: These tests were made at the testing laboratory of the Washington University, for the Reinforced-Concrete Construction Co., of St. Louis, Mo., who were acting by request of the Board of Appeals of the Building Department of the city. The tests were performed under the direction of Prof. J. L. Van Ornum, M. Am. Soc. C. E., of the Civil Engineering Department of the University, and were witnessed by a number of engineers, architects and contractors.

TESTS OF BOND BETWEEN PLAIN BARS AND CONCRETE.

Size, inches.	Maximum Load-Producing Rupture.	Maximum Strength, lb. per sq. in.	Limit of Elasticity, lb.	Limit of Elasticity, lb. per sq. in.	Elongation, inches,	Per cent. of Elongation.	Modulus of Elasticity.	Embedment, inches.	Surface Embedment, sq. in.	Maximum Pull, lb.	Max. Pull, lb. per sq. in.	Friction After Slipping, lb.	Friction, lb. per sq. in.
Medium Steel Bars—													
½	12,280	60,200	8,260	40,500	2.13	26⅝	29,900,000	13.8	21.7	10,050	460	7,500	340
⅝	18,510	57,500	12,640	39,300	2.30	28¾	29,300,000	16.7	32.8	14,010	430	10,100	310
¾	24,580	55,600	17,050	38,600	2.32	29	29,800,000	20.6	48.5	18,120	370	15,980	330
1	45,370	58,900	29,580	38,400	1.91	23⅞	28,600,000	25.7	80.7	31,110	390	30,510	380
1¼	75,350	60,900	48,140	38,900	1.80	22½	29,800,000	32.3	126.8	49,300	390	45,000	350
High Carbon Steel Bars—													
½	18,710	88,300	12,280	57,900	1.26	15¾	29,200,000	20.8	32.7	13,120	400	6,800	210
⅝	27,580	85,700	17,440	54,200	1.46	18¼	28,900,000	25.6	50.3	18,360	370	12,000	240
¾	48,430	109,600	26,820	60,700	1.10	13¾	30,600,000	32.5	76.6	29,930	390	20,600	270
1	76,470	95,500	42,560	53,100	1.56	19½	29,700,000	32.7	102.7	48,260	470	29,000	280
1¼	101,330	83,900	65,940	54,600	1.66	20¾	30,400,000	50.5	198.3	66,140	330	39,320	200

By mutual understanding between the engineers of the Building Department, the engineers of the Reinforced-Concrete Construction Co., and Professor Van Ornum, it had been agreed that a series of five tests should be made on medium steel bars, and another series of five tests should be made on high carbon steel bars. The bars used were round, and of ½, ⅝, ¾, 1 and 1¼-in. diameter. They were embedded in concrete prisms, the cross section of which was uniformly 12x12-in. for all tests. The lengths of embedment were twenty-five times the diameter of the bar tested for the medium steel, and forty times the diameter of the bar tested for the high carbon steel (with one accidental exception.) The concrete was a 1:2:4 mixture using Red Ring cement, Mississippi River sand and gravel, in a moderately wet mix.

The bars were embedded in the concrete on Aug. 30, 1907. The wooden forms were removed from the prisms after six weeks, and the bonding tests were made ninety days after the bars had been embedded in the concrete, viz: on Nov. 29 and 30. These tests have set forth the following facts of interest:

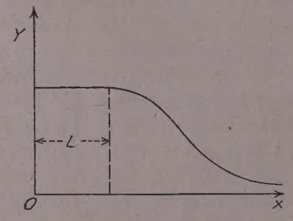
1. On every one of the bars tested, the first slip occurred shortly after the elastic limit of the steel had been reached, which tends to show, regardless of any figures, that the bond between a plain bar and the concrete in which it is embedded, is fully developed until the elastic limit of the steel is reached, then the steel begins to stretch and the bond is slowly destroyed from one section to the other.

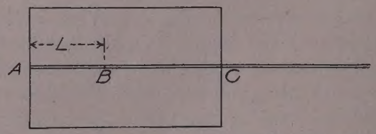
2. That after the bond proper had been destroyed there still remained a considerable friction.

3. That the maximum bond obtained per square inch of surface in contact was 460 lb. on medium steel, the minimum being 370 lb. That the maximum bond obtained per square inch of surface in contact was 470 lb. for high carbon steel, the minimum being 330 lb.

4. That higher values per square inch of the ultimate bonding stresses would have undoubtedly been obtained, had the lengths of embedment been shorter. In fact, the 1-in. bar of high carbon steel, which had been accidentally embedded in the concrete only 32.7 in. instead of 40 in., gave a bond per square inch up to 470 lb., a higher value than any other one of the same series. This fact tends to prove that there is very likely for a bar of a given diameter, a certain length of embedment corresponding to a maximum value of the bonding stress per square inch of surface in contact; and taking that length of embedment for a basis, that the bonding stress per unit surface decreases when the length of embedment increases.

In other words, if a bar of a given diameter is given different embedments in a prism of concrete, if the embedments are plotted in abscissas, x, and if for each embedment the bonding stress y, is determined, and these are plotted in ordinates, the resulting diagram would be as shown in the accompanying sketch. These, of course, are purely theoretical assumptions, and it would be interesting to verify them by a series of experiments.





Let L be the length of embedment corresponding to the maximum bonding stress per unit, then let us consider a prism of concrete in which is embedded a bar of diameter D. The fact that the bar begins to slip slightly after its elastic limit is reached leads to the belief that the length L produces anchorage of the bar in the concrete, and that the bar begins to stretch at or around the section B. The bar stretching from B to C, naturally its diameter decreases and therefore its bond between B and C is slowly destroyed. Then the pull on the bar is sufficient to overcome the bond between the portion AB of the bar and the concrete, and consequently the bar begins to slip.

Another interesting feature set forth by these experiments is the fact that after the bond proper has been destroyed, there still remains a considerable friction as mentioned above.

As the allowable tensile stress on a bar is taken at 40 per cent. of its elastic limit, if we assume an allowable safe bonding stress of 80 lb. per square inch in contact, the fact that there still remained a friction of about 200 lb. per square inch shows that the bond proper of 80 lb. insures a safety of 40 per cent. on the ultimate friction, should the bond have been prematurely destroyed.

Respectfully yours,
REINFORCED CONCRETE CONSTRUCTION CO.
St. Louis, Dec. 24.

AN ELECTRICALLY-OPERATED MINE PUMPING PLANT has been supplied by the firm of Emil Sinell, of Berlin, Germany, to the Carlshof Mines, near Tarnowitz, in Upper Silesia. The installation consists of a Brown-Boveri tri-phase, 2,000-volt, 950-h.-p. motor driving a centrifugal pump which lifts 2,200 gal. per minute through 103 ft.